The Impact of Brazil's ABC Program Credit on Pasture Recovery: Evidence from the Cerrado

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CLIMATE POLICY INITIATIVE

PUC RIO

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About Climate Policy Initiative

Climate Policy Initiative (CPI) is an analysis and advisory organization with deep expertise in finance and policy. CPI has seven offices around the world. In Brazil, CPI has a partnership with the Pontifical Catholic University of Rio de Janeiro (PUC-Rio). CPI/PUC-RIO supports public policies in Brazil through evidence-based research and strategic partnerships with members of the government and civil society.

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List of Figures and Tables

List of Acronyms and Abbreviations

ABC Plan Agricultural Sector Plan for Climate Change Mitigation and Adaptation for the Consolidation of a Low-Carbon Economy (*Plano Setorial de Mitigação e de Adaptação às Mudanças Climáticas para a Consolidação de uma Economia de Baixa Emissão de Carbono na Agricultura*)

ABC+ Plan Brazilian Agricultural Policy for Climate Adaptation and Low Carbon Emission (*Plano de Adaptação e Baixa Emissão de Carbono na Agricultura*)

ABC Program National Program for Low-Carbon Emissions in Agriculture (*Programa para Redução da Emissão de Gases de Efeito Estufa na Agricultura*)

BCB Central Bank of Brazil (*Banco Central do Brasil*)

BNDES Brazilian Development Bank (*Banco Nacional de Desenvolvimento Econômico e Social*)

CMN National Monetary Council (*Conselho Monetário Nacional*)

CPI/PUC-RIO Climate Policy Initiative/Pontifical Catholic University of Rio de Janeiro

EMBRAPA Brazilian Agricultural Research Corporation (*Empresa Brasileira de Pesquisa Agropecuária*)

EVI Enhanced Vegetation Index

FCFs Constitutional Financing Funds (*Fundos Constitucionais de Financiamento*)

FINAME Fund for the Purchase of Industrial Machines and Equipment (*Fundo de Financiamento para Aquisição de Máquinas e Equipamentos Industriais*)

GHGs Greenhouse Gases

IMAFLORA Institute for Agricultural and Forest Management and Certification (*Instituto de Manejo e Certificação Florestal e Agrícola*)

IPCA Extended National Consumer Price Index (*Índice Nacional de Preços ao Consumidor Amplo*)

LAPIG Image Processing and Geoprocessing Laboratory (*Laboratório de Processamento de Imagens e Geoprocessamento*)

LULUCF Land Use, Land Use Change, and Forestry

MAPA Ministry of Agriculture and Livestock (*Ministério da Agricultura e Pecuária*)

MAPBIOMAS Brazilian Annual Land Use and Land Cover Mapping Project *(Projeto de Mapeamento Anual do Uso e Cobertura da Terra no Brasil)*

MCR Rural Credit Manual (*Manual de Crédito Rural*)

MCTI Ministry of Science, Technology and Innovation (*Ministério da Ciência, Tecnologia e Inovação*)

MODIS Moderate Resolution Imaging Spectroradiometer

OLS Ordinary Least Squares

NDC Nationally Determined Contribution

PNCPD National Program for the Conversion of Degraded Pastures into Sustainable Agricultural and Forestry Production Systems (*Programa Nacional de Conversão de Pastagens Degradadas em Sistemas de Produção Agropecuários e Florestais Sustentáveis*)

PROAGRO Agricultural Activity Guarantee Program (*Programa de Garantia da Atividade Agropecuária*)

RECOR Common Record of Rural Operations (*Registro Comum de Operações Rurais*)

RENOVAGRO Program for Financing Sustainable Agricultural Production Systems (*Programa de Financiamento a Sistemas de Produção Agropecuária Sustentáveis*)

SIBCS Brazilian Soil Classification System (*Sistemas Brasileiro de Classificação de Solos*)

SICOR Rural Credit and PROAGRO Operations System (*Sistema de Operações do Crédito Rural e do PROAGRO*)

SPS_{ABC} Sustainable Production Systems, Practices, Products, and Processes of ABC+ Plan (*Sistemas, Práticas, Produtos e Processos de Produção Sustentáveis do Plano ABC+*)

UFG Federal University of Goiás (*Universidade Federal de Goiás*)

Contents

Introduction

Recovering degraded pastures presents a unique opportunity to sustainably boost Brazilian agricultural production. This can be achieved through increased cattle productivity or by converting these areas into agricultural crops or by integrating crop-cattle-forest systems. Currently, around two-thirds of Brazil's pastures, equivalent to 100 million hectares, are degraded (MAPBIOMAS nda). Recovering these areas avoids the need for further deforestation to expand agricultural production.

In this regard, Brazil has committed to recovering 30 million hectares of pasture by 2030 in its Nationally Determined Contribution (NDC) (República Federativa do Brasil 2016). The government has launched a concentrated effort to seek resources in the order of US$ 120 billion from abroad to implement a program that seeks to recover 40 million hectares.[1] It is crucial to ensure that the application of these resources is effective in meeting the target and promoting the necessary balance between the expansion of food production and the preservation of native vegetation in the country to address the challenge of the climate emergency.[2]

In this report, **researchers from Climate Policy Initiative/Pontifical Catholic University of Rio de Janeiro (CPI/PUC-RIO) evaluate the effectiveness of the *ABC Recuperação* credit line, the main public policy instrument for recovering degraded pastures in Brazil implemented in recent years**. The study calculates the impacts of credit on the degree of pasture degradation and on changes in land use in the areas declared to receive these investments. As this is a costly investment, subsidized credit can facilitate the recovery process by reducing costs compared to the expansion of economic activity into areas of native vegetation. However, it is crucial to determine whether the provision of credit generates effective results.

The study shows that the effects of *ABC Recuperação* credit are modest. Pasture areas with the most severe signs of degradation remain practically unchanged after receiving credit. The study also found a marginal reduction in pasture area, with converted areas showing minimal signs of degradation. The analysis also reveals that the areas accessing *ABC Recuperação* credit experienced deforestation in the years prior to receiving credit, but this trend was changed after the credit was issued.

1 This is the National Program for the Conversion of Degraded Pastures into Sustainable Agricultural and Forestry Production Systems (*Programa Nacional de Conversão de Pastagens Degradadas em Sistemas de Produção Agropecuários e Florestais Sustentáveis* - PNCPD). Learn more at: bit.ly/3LQeXIP.

2 This is especially important considering that the majority (67%) of Brazil's greenhouse gas (GHG) emissions come from Land Use, Land Use Change, and Forestry (LULUCF) and the agriculture sector, according to official estimates from the national inventory (MCTI 2022).

The results suggest that the availability of credit is not sufficient to leverage the recovery of degraded pastures in Brazil, especially considering that the areas analyzed correspond to the specific portion of the rural property declared to receive these investments. CPI/PUC-RIO's analysis identifies room for improvement in the program, particularly in terms of more effective monitoring of compliance with the technical project submitted to obtain the credit. It is necessary to better understand the challenges preventing recovery from occurring on the desired scale and to assess how credit can be associated with other interventions, such as technical assistance and agriculture risk management instruments. Additionally, changes in land use in these areas should be monitored before credit is issued to focus the program on producers who consistently adopt good practices.

The credit for pasture recovery is part of the National Program for Low-Carbon Emissions in Agriculture (*Programa para Redução da Emissão de Gases de Efeito Estufa na Agricultura* - ABC Program),[3] which is one of the instruments associated with the Agricultural Sector Plan for Climate Change Mitigation and Adaptation for the Consolidation of a Low-Carbon Economy *(Plano Setorial de Mitigação e de Adaptação às Mudanças Climáticas para a Consolidação de uma Economia de Baixa Emissão de Carbono na Agricultura* - ABC Plan), the main policy for promoting sustainable agriculture practices in the country. The credit line provides resources for investment at subsidized interest rates with an extended repayment period. Therefore, the public resources mobilized in this program must generate returns for society in the form of productivity gains, more sustainable land use, and reduced pressure from deforestation. Additionally, it is essential to ensure that other potentially larger-scale initiatives, such as the recently launched National Program for the Conversion of Degraded Pastures into Sustainable Agricultural and Forestry Production Systems (*Programa Nacional de Conversão de Pastagens Degradadas em Sistemas de Produção Agropecuários e Florestais Sustentáveis* - PNCPD) are effective from the outset.[4]

3 After being renamed the ABC+ Program from the time of the ABC+ Plan (2021-2030), the program received a new name from the 2023/24 Brazilian Agricultural Plan: Program for Financing Sustainable Agricultural Production Systems (P*rograma de Financiamento a Sistemas de Produção Agropecuária Sustentáveis* - RENOVAGRO).

4 The program, established by Decree no. 11,815/2023, is expected to recover 40 million hectares of degraded pastures. The details of its implementation are being worked out by an inter-ministerial management committee.

Results and Policy Recommendations

This study evaluates the effects of *ABC Recuperação* credit on the areas declared for recovering degraded pasture using satellite images. The analysis considers credit operations that took place between 2016 and 2018 in the Cerrado biome and observes the effects through 2022.[5] The researchers matched the georeferenced polygons of the Central Bank of Brazil's (*Banco Central do Brasil* - BCB) rural credit operations with data on land use and pasture quality from the Brazilian Annual Land Use and Land Cover Mapping Project *(Projeto de Mapeamento Anual do Uso e Cobertura da Terra no Brasil* - MAPBIOMAS) and the Image Processing and Geoprocessing Laboratory (*Laboratório de Processamento de Imagens e Geoprocessamento* - LAPIG) of the Federal University of Goiás (*Universidade Federal de Goiás* - UFG). Based on this data, an econometric methodology is applied to identify the causal effects of credit in these areas over a period ranging from four to six years after the credit was issued.

Results

The study finds that the effects of *ABC Recuperação* credit are, on average, very modest.

Pasture Recovery and Conversion

- **Analysis of land use transitions in the financed areas for pasture recovery indicate that three-quarters of the area of the polygons remains unchanged four years after receiving credit.**
- **No significant effects are observed in pasture areas with signs of more severe degradation**, represented by areas of low quality.[6]
- Obtaining credit is associated with an **average reduction of 3 percentage points (p.p.) in the pasture area** of these polygons. Even for polygons that received credit in 2016 and were analyzed six years later, this effect reaches a maximum of 10 percentage points. **This reduction is mainly in areas with less evidence of degradation.**

5 The focus on the Cerrado biome is justified by the greater precision of the measure of pasture degradation compared to other biomes, while the time restriction is justified by observing the effects over a period of at least four years after the credit is issued. In any case, the results are similar when considering all biomes and years. More details in the data and methodology sections.

6 Since pasture vegetation vigor is a measure for pasture quality in terms of degradation levels, the terms "pasture vigor" and "pasture quality" are used interchangeably in this report.

- There is evidence that this **pasture area is being converted to other economic uses.** There is an average increase of 1 p.p. in crop areas and 1.1 p.p. in the crop-cattle mosaic areas, which is an area not distinguishable between crop and pasture from satellite images.

Technical Assistance and Soil Type

- **Technical assistance is a determining factor in the effectiveness of credit for pasture recovery**. Polygons associated with credit contracts with the acquisition of technical assistance had a significant reduction of 6 p.p. in the area of degraded pasture four years after the credit was issued, while the quality of the pastures was practically unchanged for those who did not hire the service. Even so, the results are modest.
- This finding **corroborates other evidence** produced by CPI/PUC-RIO on the importance of technical assistance to promote the recovery of degraded pastures in the country (Bragança et al. 2022; Souza et al. 2022).
- **The success of investment in pasture recovery also varies according to soil conditions.** The effects of reducing pastures with signs of degradation are stronger, for example, in areas where the predominant soil type is Plithosols, especially in areas of the states of Mato Grosso, Tocantins, and Maranhão.

Deforestation

- Before the credit was issued, findings show evidence of **deforestation in the areas declared for pasture recovery**. These areas experienced a 5 p.p. decrease in the average proportion of native vegetation in the six years prior to receiving credit. After receiving credit, this trend changed.

ABC Plan Targets

- The ABC Plan's target was to recover 15 million hectares of degraded pasture by 2020. **It is estimated that the contribution of the *ABC Recuperação* credit was at most 2.5% of this target**, considering the effect on the conversion of pastureland to other uses.
- **If 100% of the pasture areas declared in *ABC Recuperação* credit operations were recovered, the contribution would have been 18% of the target**. This indicates that reaching the target depends heavily on other public policy instruments, other lines of credit, or the spontaneous adoption of degraded pasture recovery practices by producers.

Robust Results

- **The effects found hold up to a series of sensitivity analyses.** The general conclusions remain consistent when the analysis is carried out for: 1) all biomes; 2) credit operations conducted between 2016 and 2021; 3) different polygon sizes; 4) different specifications of control variables by other factors; and 5) restricting the polygons declared only to pasture areas at the time of obtaining the credit, removing areas such as forest and crops.

Recommendations

- **The subsidized credit policy as it is currently designed may be insufficient for the necessary transformation of degraded pastures in Brazil.** It is crucial to increase the effectiveness of this instrument to ensure that public resources are properly directed, generating positive environmental and climate effects.
- It is essential to **improve the monitoring** of the areas after credit has been released and to monitor **compliance with the technical project** submitted to obtain the funds.
- In addition to monitoring by financial institutions, which focuses on assessing payment conditions and the application of resources, it is necessary to **technically assess the environmental conditions of the projects**, in order to understand the challenges faced by producers in relation to pasture recovery techniques. A cost-effective way of implementing this verification is through sampling.
- Additionally, the **declaration of the areas that will receive these investments must accurately reflect the pasture area to be recovered**. More than a quarter of the areas declared do not correspond to pasture at the time the credit is issued.
- The evidence of deforestation before credit is granted suggests the need for better evaluation of **the areas declared before funds are released and focusing credit** on producers who consistently adopt good practices.
- **Combining credit with other public policy instruments can increase its effectiveness.** In particular, **technical assistance is crucial**, especially for recovering the most degraded areas, which require more complex interventions. It is necessary to ensure that management and maintenance techniques are applied properly and consistently.[7]
- **Combining credit with risk management instruments** can also maximize its impact. The success of recovery may depend on factors beyond the producer's control, such as variations in the weather and prices. Therefore, it is important to increase the availability of **longer-term rural insurance policies.**
- During the implementation period of the techniques, part of the area may become unviable for economic use. Providing **transitional income** in the first years of the operation, especially for smaller producers, can increase the economic viability of the investment.[8]
- Subsidized credit for recovering degraded pastures is an important tool, as it allows producers to make the necessary investments with less exposure to risk, given that these operations are long-term. **However, expanding resources without increasing their effectiveness is insufficient.**
- The results of the *ABC Recuperação* credit **should be evaluated within the context of other policies, such as the PNCPD**, which seeks to achieve an even larger scale than the ABC Program.

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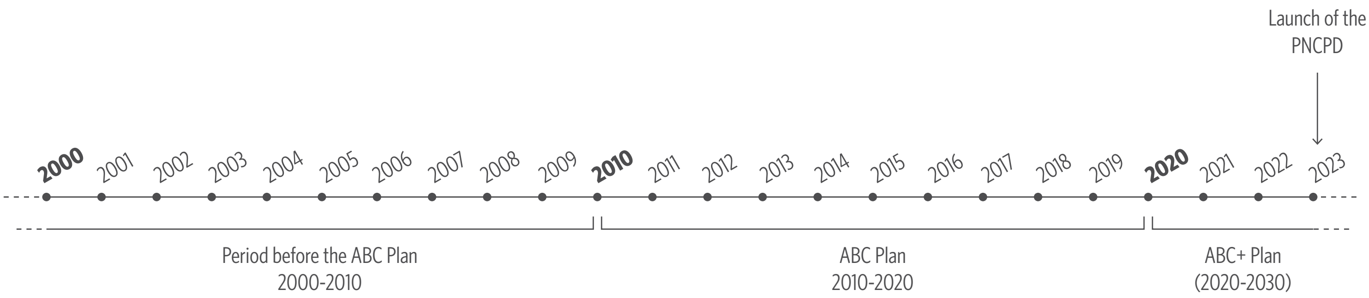
7 The recommendation to expand technical assistance associated with credit contracts for sustainable practices (in particular, the recovery of degraded pastures) also appears in documents from the Brazilian Development Bank (*Banco Nacional de Desenvolvimento Econômico e Social* - BNDES) (Lopes, Sowery and Peroba 2016), the Brazilian Agricultural Research Corporation (*Empresa Brasileira de Pesquisa Agropecuária* - EMBRAPA) and the World Bank (Santos et al. 2024), for example.

8 One possibility would be to design financial products that allow borrowers to access funds in the first year of the operation, until the new production system has been implemented. These resources could be repaid as part of the loan in the future or even have a non-repayable portion, if compliance with the goals established in the technical project regarding the recovery of degraded pastures is verified (Lopes, Sowery, and Peroba 2016).

Context

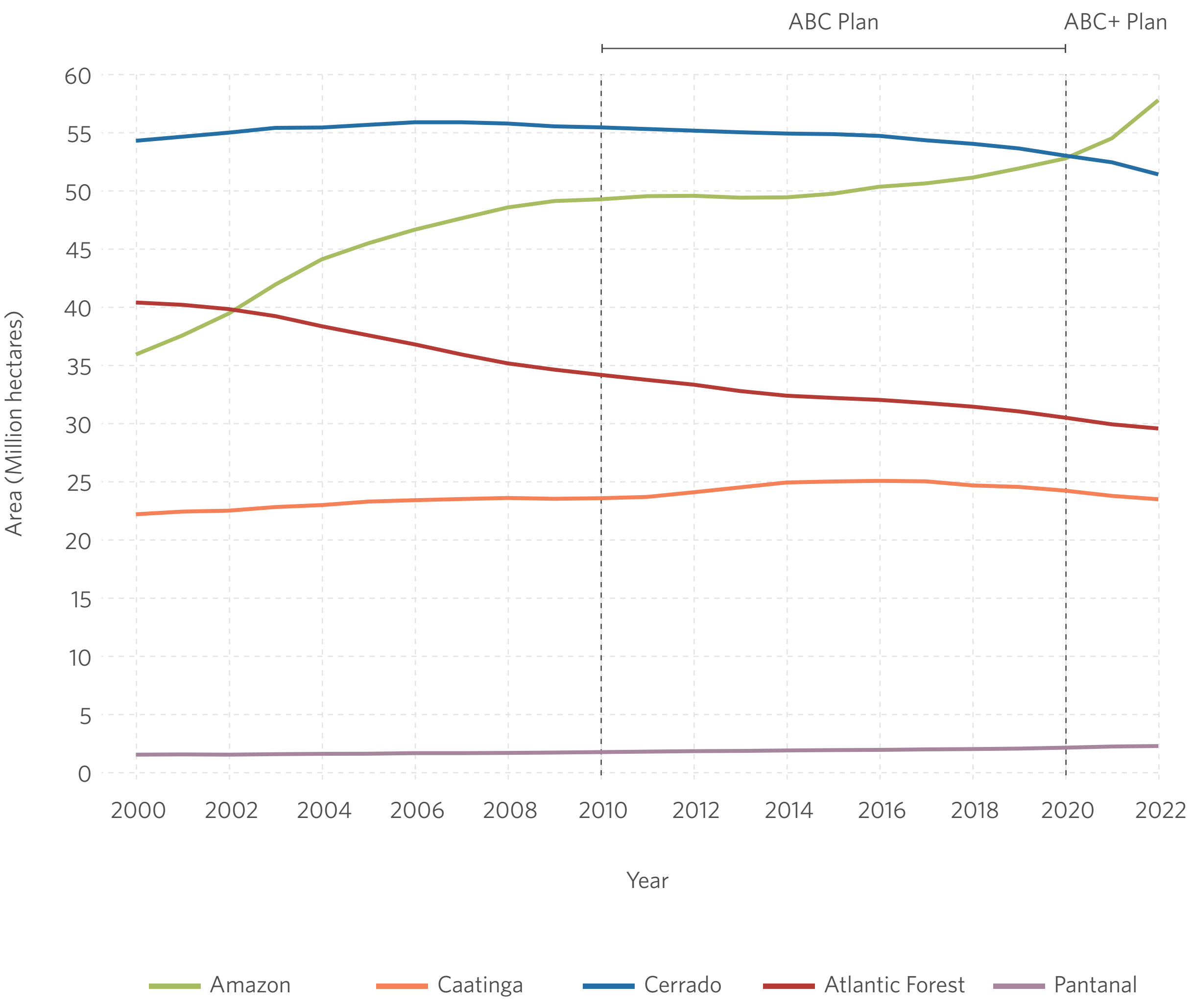


Note: *The study's analysis period is from 2000 to 2022 due to the availability of pasture quality data from MAPBIOMAS.*

Pastures in Brazil

Currently, around one-fifth of the entire national territory is made up of pasture, approximately 160 million hectares (Souza et al. 2020). Pasture areas grew during the 2000s, followed by a period of relative stability during the ABC Plan (2010-2020), as shown in **Figure 1**. However, pasture areas have started to grow again in the last two years, during the period of the Brazilian Agricultural Policy for Climate Adaptation and Low-Carbon Emission (*Plano de Adaptação e Baixa Emissão de Carbono na Agricultura* - ABC+ Plan) (2021-2030), the main Brazilian government initiative to promote low-carbon emission practices in agriculture. Historically, the Cerrado biome has concentrated most of Brazil's pastures. However, the Amazon biome has seen the largest increase in pasture area over the period, making it the biome with the largest share of Brazilian pastures. These data indicates that agricultural production areas continue to expand even today.

Figure 1. Pasture Area by Biome, 2000–2022



Note: *The natural pastures of the Pampa are considered non-forest natural formations in MAPBIOMAS.*
Source: *CPI/PUC-RIO with data from MAPBIOMAS (2022), 2024*

Additionally, 62% of Brazil's pastureland shows signs of degradation, according to LAPIG/MAPBIOMAS data for 2022. For the Cerrado, this percentage is even higher at 68%. Pasture quality affects both the soil's carbon retention capacity and cattle productivity. The process of pasture degradation is associated with inadequate management practices, leading to soil compaction, a reduction in vegetation quality and forage availability, an increase in invasive plants, soil erosion and the occurrence of pests.

The process of recovering degraded pastures makes it possible to increase cattle productivity or convert areas to crop production, reducing the need to expand production extensively and helping to address the climate emergency. Recovery can occur in various ways depending on the level of pasture degradation, including soil management practices and the cultivation of forage plants. Enterprises in areas with higher pasture quality have greater nutritional value for their cattle, reduce methane emissions, lower production costs and generate more resilience against periods of drought. The difference in meat productivity between degraded pastures and recovered, well-managed pastures can be up to six times greater (Zimmer et al. 2012). Therefore, correcting or renovating pastures with signs of degradation is crucial for more productive land use and for reducing greenhouse gases (GHGs) emissions.

The general trends for the period 2000-2022 suggest that Brazilian pastures are following a path of decreasing degradation, with an increase in areas with no signs of degradation (high quality) and a decrease in areas with signs of severe degradation (low quality). **Figure 2** shows the pasture area in each quality class based on LAPIG/MAPBIOMAS data for Brazil and with a cut-out for the Cerrado. This trend was already observed both in Brazil as a whole and specifically in the Cerrado even before the ABC Plan came into force in the 2010s. The overall picture shows an intensification of this trend in the second half of the ABC Plan period. Despite this improving trend, most pasture areas still exhibit some level of degradation. Furthermore, the trend towards improvement was interrupted in more recent years when the ABC+ Plan came into force.

In addition, between 2000 and 2022, Brazil lost 50 million hectares of native vegetation, making way for an additional 47 million hectares of agriculture use. Of this additional area, 10 million hectares remained as pasture in 2022. The increase in pasture area occurred mainly before the ABC Plan came into force, but as shown above, it has happened again in more recent years. Furthermore, this pasture area has undergone a qualitative transformation, with a decrease of 16 million hectares of low quality pasture, an increase of 4 million hectares of pasture with signs of moderate degradation (medium quality) and almost 23 million hectares more of high quality pasture. It is worth noting that the decrease in low quality pastures had already been occurring before the ABC Plan came into force and halted in recent years during the period the ABC+ Plan.

In the Cerrado, there is a tendency for areas of low quality (-7.7 million hectares) to be transferred to high quality (+4.9 million hectares) between 2000 and 2022, signaling an effort to recover degraded areas. The net drop in pasture area stems from conversion to crops and other uses. Despite this, the biome also saw a significant drop in the area of native vegetation, losing 15.4 million hectares during this period. As in the general picture, the Cerrado has also experienced an interruption in the qualitative transformation of pastures in recent years, with a new increase in low quality pastures and a decrease in high quality pastures.

The existence of these areas to be recovered demonstrates a great potential for carbon retention, both through pasture recovery itself and by reducing the pressure for new pasture areas. This indicates an opportunity for public policies in Brazil to create institutional environments that encourage this recovery. This work seeks to assess whether the instruments applied so far have been effective in promoting part of the observed improvement.

Figure 2. Area by Land Use Type and Pasture Quality Class in Millions of Hectares, 2000, 2010, 2020, and 2022, Brazil and Cerrado

BRAZIL

Land Uses	2000	2010	2020	2022	Difference 2010 - 2000	2020 - 2010	2022 - 2020	2022 - 2000
Native Vegetation	592.6	566.7	550.9	543.0	-25.9 ↓	-15.8 ↓	-7.9 ↓	-49.6 ↓
Agriculture	235.4	260.8	276.6	282.5	25.4 ↑	15.8 ↑	5.9 ↑	47.1 ↑
Pasture	154.2	164.0	162.5	164.3	9.9 ↑	-1.6 ↓	1.2 ↑	10.3 ↑
Low Quality Pasture	51.2	41.4	32.5	34.8	-9.8 ↓	-8.9 ↓	2.3 ↑	-16.4 ↓
Medium Quality Pasture	62.9	70.1	67.9	66.7	7.1 ↑	-2.1 ↓	-1.2 ↓	3.9 ↑
High Quality Pasture	40.1	52.6	62.1	62.8	12.5 ↑	9.4 ↑	0.8 ↑	22.7 ↑
Other Uses	22.7	23.1	23.2	25.2	0.4 ↑	0.1 ↑	2.0 ↑	2.5 ↑

CERRADO

Land Uses	2000	2010	2020	2022	Difference 2010 - 2000	2020 - 2010	2022 - 2020	2022 - 2000
Native Vegetation	110.4	102.3	96.3	95.0	-8.1 ↓	-6.0 ↓	-1.2 ↓	-15.4 ↓
Agriculture	85.2	93.0	98.9	99.5	7.8 ↑	5.9 ↑	0.6 ↑	14.3 ↑
Pasture	54.3	55.4	53.0	51.4	1.2 ↑	-2.4 ↓	-1.6 ↓	-2.9 ↓
Low Quality Pasture	21.8	16.8	13.1	14.1	-5.0 ↓	-3.7 ↓	1.0 ↑	-7.7 ↓
Medium Quality Pasture	20.9	22.9	21.6	20.9	1.9 ↑	-1.2 ↓	-0.7 ↓	0.0
High Quality Pasture	11.5	15.7	18.2	16.4	2.5 ↑	2.5 ↑	-1.9 ↓	4.8 ↑
Other Uses	2.8	3.1	3.2	3.9	0.1 ↑	0.1 ↑	0.7 ↑	1.1 ↑

Note: *The native vegetation category includes areas of native forest and non-forest natural formations. The agriculture category includes areas of crops, pastures, planted forests and the crop-cattle mosaic, which is an undefined area between crops and pastures. The total pasture area considered is that reported by the MAPBIOMAS land cover and land use collection. The values for the pasture quality classes were obtained by applying the percentages of each class to this total pasture, since the sum of the three "vigor" (quality) classes does not generate exactly the same total pasture value in the pasture quality collection. The "other uses" category is the difference between the total area and the native vegetation and agriculture categories.*
Source: *CPI/PUC-RIO with data from LAPIG/MAPBIOMAS (2022), 2024*

The ABC Program (RENOVAGRO)

The ABC and ABC+ plans set ambitious targets "to promote adaptation to climate change and get control of greenhouse gas (GHG) emissions in Brazilian agriculture, with increased efficiency of production systems through integrated landscape management." (MAPA 2021, p. 14). One key strategy explored is pasture recovery, which is provided for in the Sustainable Production Systems, Practices, Products and Processes of ABC+ Plan (*Sistemas, Práticas, Produtos e Processos de Produção Sustentáveis do Plano ABC+* - SPS_{ABC}). Initially, the ABC Plan aimed to recover 15 million hectares of degraded pastures between 2010 and 2020. The ABC+ Plan has broadened this goal, targeting 30 million hectares for recovery between 2021 and 2030.

The plans rely on a series of initiatives, including incentives for technical innovations, technical assistance for producers and a financial arm operated through rural credit policy.[9] This instrument—initially called the ABC Program (ABC+ Program as of the ABC+ Plan) and then renamed, in 2023, the Program for Financing Sustainable Agricultural Production Systems (*Programa de Financiamento a Sistemas de Produção Agropecuária Sustentáveis* - RENOVAGRO)—is responsible for providing subsidized credit for investments adopting the sustainable agricultural practices outlined in the SPS_{ABC}.

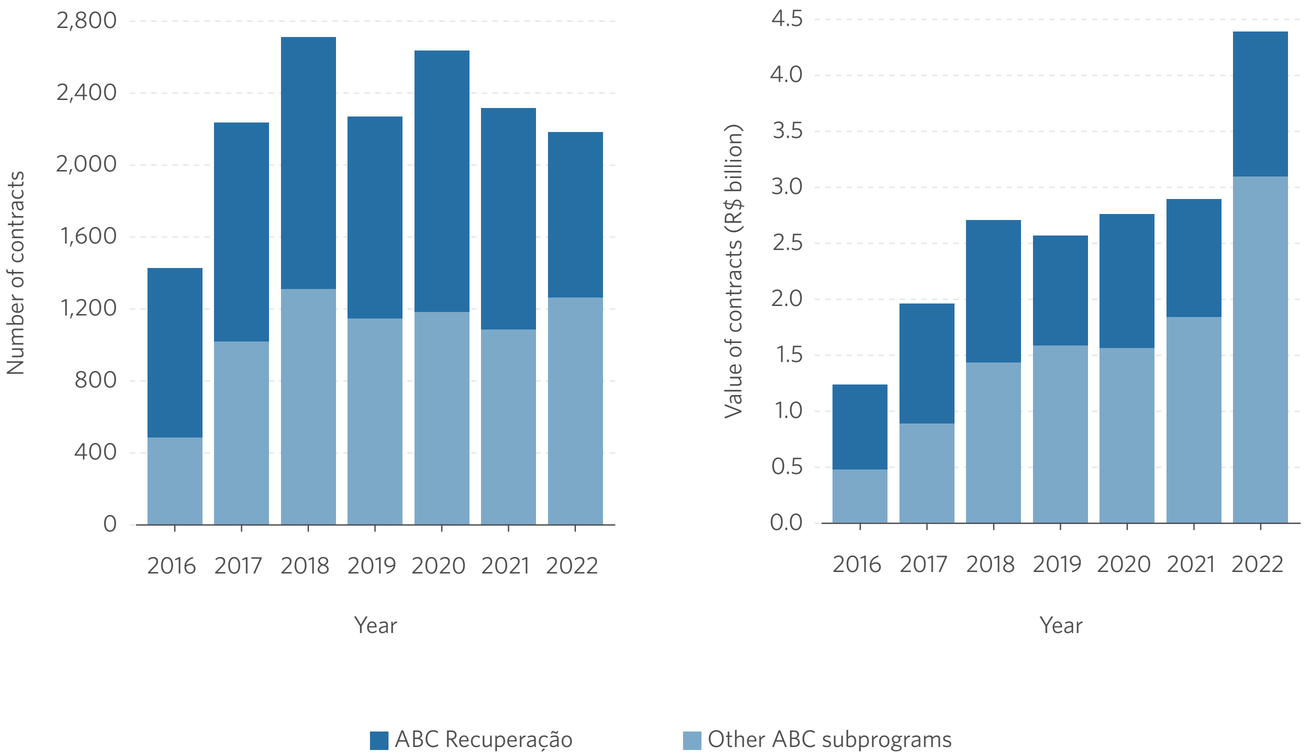
The ABC Program accounts for a small portion of the total rural credit under the Brazilian Agricultural Plan (*Plano Safra*), the main financial policy for the country's agriculture sector. In the period under analysis (2016-2022), the program accounted for just over 1% of the resources released for rural credit. Catering mainly to medium-sized rural producers, ABC Program contracts had a relatively high average value of R$ 870,000 during the period, at December 2020 prices.

ABC Recuperação, a line of credit aimed specifically at pasture recovery, is one of the ABC's main subprograms. **Figure 3** shows that the sub-program corresponds to 53% of the contracts and 41% of the value of the entire ABC Program released between 2016 and 2022.[10] Despite the relative stability in the annual number of contracts from 2017 onwards, the total value contracted has increased over time, especially in 2022, reflecting contracts with an increasing average value.

9 Officially, the ABC Program was created by CMN Resolution no. 3,896/2010.

10 The average value of the contract in the *ABC Recuperação* subprogram is R$792,000 (at December 2020 prices), slightly lower than the overall average value of the ABC Program shown above.

Figure 3. Number of Contracts and Value of the ABC Program by Subprogram, 2016–2022



Note: *Monetary values adjusted by the IPCA in December 2022.*
Source: *CPI/PUC-RIO with data from SICOR/BCB (2024), 2024*

ABC Recuperação offers access to credit at a lower interest rate than that available on the market. In the 2024/25 Brazilian Agricultural Plan, the rate was 7% per year, while the basic interest rate (Selic) in force when the plan was announced (in July 2024) was 10.5%.[11] According to the Rural Credit Manual (*Manual de Crédito Rural* - MCR), payment terms are long and can reach up to 10 years with a grace period of up to five years. The credit limit per agricultural year is R$ 5 million. To gain access, the farmer needs a specific technical project, signed by a qualified professional, stating the identification of the property and the total area of the property. Additionally, proof of soil analysis and an agriculture management plan covering the project area are required. The credit line can finance various items such as intensive soil correction, liming, growing fodder plants, technical assistance, and the purchase of animals.

The credit line was designed to ease producers' financial constraints, given that restoring pastures is an expensive and risky investment. In addition to the associated costs, such as rendering the area unusable for a period, there is the risk of not achieving the expected results. Choosing the type of recovery, as well as the operations and inputs needed, requires a detailed diagnosis of the pasture's conditions, seeking to understand which intervention is most appropriate for the level of degradation found. Additionally, maintaining the recovered pasture requires the continuous application of management techniques, such as maintenance fertilization and control of stocking and grazing height (Euclides et al. 1999). Replenishing

11 In the previous Brazilian Agricultural Plan (2023/24), this difference was even greater, since the *ABC Recuperação* credit rate was the same (7%) and the Selic rate was 13.75% in June 2023.

nutrients in the soil is crucial to the success of recovery and lowers the cost of the operation in the long term, as the cost of new recovery is substantially higher (Zimmer et al. 2012). For these reasons, access to technical assistance for the producer is essential to guarantee the effectiveness of the investment in pasture recovery (Bragança et al. 2022; Souza et al. 2022).

Considering the ABC+ Plan's goal of recovering 30 million hectares of degraded pasture by 2030, the area associated with *ABC Recuperação* credit is relatively small. As shown in the next section, it is possible to obtain the polygons financed by the program from the database of the BCB. The sum of the area of the polygons financed between 2016 and 2022 (which had their coordinates reported) results in 1.5 million hectares. Even so, credit is one of the main tools of the ABC Plan and during this period it mobilized more than R$6 billion for the *ABC Recuperação* credit line, much of which is subsidized.[12] For this reason, it is essential to evaluate the effectiveness of this policy, seeking to understand the extent to which these areas are actually recovering pasture, as well as identifying their limitations. With this understanding, it is possible to propose recommendations for improvement based on scientific evidence.

12 Data from the Rural Credit Data Matrix (BCB nda).

Data

To produce the results, georeferenced information from subsidized rural credit operations was matched with remote sensing data on land use, pasture quality, and secondary vegetation in Brazil, as well as information on the predominant soil types. The organization of the data is detailed below.

Rural Credit Data

The rural credit data was obtained from the BCB's public microdata base of the Rural Credit and PROAGRO Operations System (*Sistema de Operações do Crédito Rural e do PROAGRO* - SICOR). This database records the disbursement of funds for all rural credit operations in the country, detailing the amount released, credit programs, financial institution, purpose and type of credit, among others. Due to banking secrecy issues, only credit operations involving subsidized resources[13] provide information enabling the identification of the borrower and the location of the enterprise, including its geodetic coordinates, when applicable.[14] This is the case for nearly all *ABC Recuperação* Program operations.[15] Consequently, it is possible to recover the geographical area associated with credits for pasture recovery, referred to as a "gleba". The study therefore analyzes the impact of credit on the areas declared to receive interventions to recover degraded pastures.

The geodetic coordinates (latitude and longitude) that precisely identify the boundaries of the polygon of the enterprise associated with credit began to be reported in SICOR in 2016. Since then the range of operations required to report this information has progressively expanded. According to MCR 2-1-2, it now encompasses all "rural credit operations for working capital and investment linked to a delimited rural property area" (BCB ndb, as translated by the authors[16]). The resolutions of the National Monetary Council (*Conselho Monetário Nacional* - CMN)[17] and the *Notícias do SICOR* portal enables the mapping of reporting requirements for each year (BCB ndc).

13 These are credit operations with equalized interest rates (which are subsidized by the government), which use public sources of finance (such as the Constitutional Financing Funds - *Fundos Constitucionais de Financiamento* - FCFs) and all operations with contracts associated with the Agricultural Activity Guarantee Program (*Programa de Garantia da Atividade Agropecuária* - PROAGRO), whose indemnity in the event of a claim is paid by the National Treasury.

14 Not every credit operation requires a declaration of coordinates, as in the case of the purchase of a machine, for example.

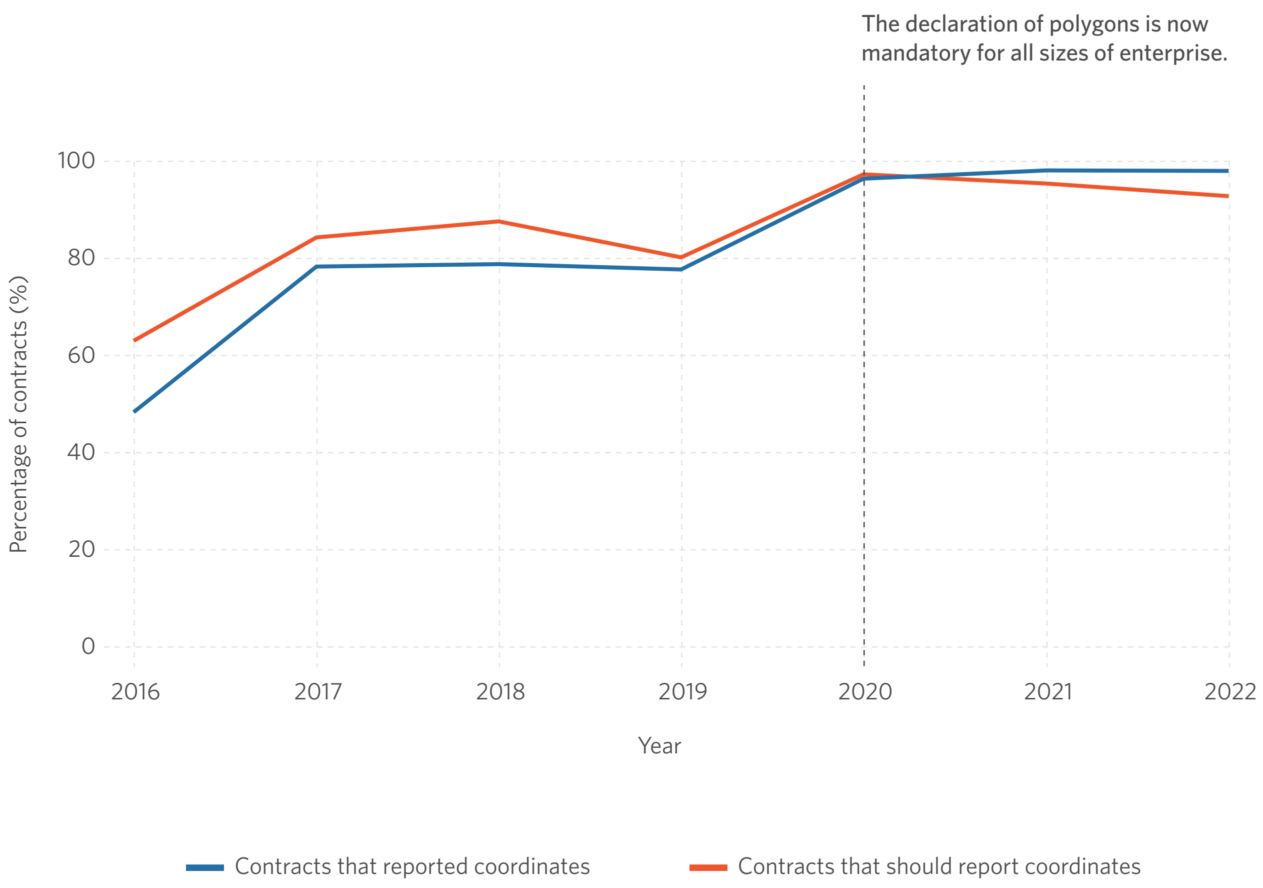
15 Between 2016 and 2022, 17,468 *ABC Recuperação* credit operations were registered with SICOR, of which 17,227 had subsidized resources. The program has interest rates set by the government, so that when these rates are lower than the financial agent's cost of funding according to the credit line's source of funds, the government bears the difference through equalization. Operations without subsidized resources are possibly cases in which the interest rate was equal to or lower than the bank's cost of funding for a specific source. In the case of *ABC Recuperação*, the main sources of funding reported in SICOR are Rural Savings and BNDES/Fund for the Purchase of Industrial Machines and Equipment (*Fundo de Financiamento para Aquisição de Máquinas e Equipamentos Industriais* - FINAME).

16 Original text: "operações de crédito rural de custeio e de investimento que estejam vinculadas a uma área delimitada do imóvel rural" (BCB ndb).

17 CMN Resolutions no. 4,174/2012, no. 4,427/2015, no. 4,496/2016, no. 4,580/2017, no. 4,685/2018, no. 4,829/2020, no. 4,830/2020, no. 4,863/2020, and no. 4,889/2021. See details in the References section, item "Legislation Consulted".

For *ABC Recuperação* contracts, the declaration of polygons became mandatory for all sizes of enterprise from 2020 onwards. Before this, there were several exceptions, for example, contracts with a low value of the operation or size of the financed area (in hectares) were exempt from reporting. **Figure 4** shows the percentage of *ABC Recuperação* contracts[18] that reported coordinates each year *versus* the percentage of contracts that were required to report according to the resolution in force for each year. From 2020 onwards, when the most relevant exceptions ceased to apply, nearly all contracts reported coordinates. Before then, the percentage reporting was slightly lower than the percentage required to report, but followed a similar trend.[19]

Figure 4. Percentage of *ABC Recuperação* Credit Contracts According to Geodetic Coordinates Reporting, 2016–2022



Note: *The percentages are calculated on the total number of ABC Recuperação credit contracts with subsidized resources.*
Source: *CPI/PUC-RIO with data from SICOR/BCB (2024), 2024*

18 Each observation in the SICOR database, referred to here as a "credit operation", is indexed by the pair of variables Central Bank ID (*ref_bacen*) and Order number (*nu_order*). However, a contract (*ref_bacen*) can have several operations associated with it. For example, in the case of *ABC Recuperação*, a contract can have an operation that reports "farm improvement", "pasture" and "training" in the modality, product and variety fields, respectively, which clearly falls within the coordinate reporting rules. But the same contract may have another operation with the modality "technical services", "purchase of machinery and equipment" or "purchase of animals" which would not need to be declared, as they are not necessarily associated with a specific area delimitation. However, this second operation is part of the same contract, so it is also associated with pasture recovery. For this reason, **Figure 4** considers whether a contract reports (or needs to report) coordinates for at least one of its linked operations.

19 The fact that it never reach 100% reporting of coordinates in *ABC Recuperação* contracts is due to a series of exceptions recorded over time on the *Notícias do SICOR* portal.

From 2016 (when the coordinates began to be reported) to 2022 (the last year of available land use and pasture quality data), subsidized resources were released for 17,227 *ABC Recuperação* credit operations. These operations are associated with 8,159 contracts, 83% of which (6,779) reported coordinates, encompassing a total of 12,823 polygons.[20] The same operation can report multiple polygons, and the same polygon can be reported by different operations in the same year or in different years.

The process of cleaning up the polygons initially involved removing duplicate plots. Some plots were repeated in the same year and, in other cases, in credit operations issued in different years. In the latter case, only the first time the gleba is reported was considered for the purposes of this analysis. Additionally, the evaluation of reported geometries included separating instances where multiple polygons were reported within the same development and removing geometries that did not correspond to polygons (such as points and lines). Reporting errors were addressed, such as plots located outside Brazilian borders (which were removed) and implausibly large or extremely elongated polygons. In these cases, polygons with a circularity index of less than 0.2 were removed.[21] Additionally, partial overlaps of polygons were resolved by prioritizing those associated with older credit operations, leading to the redefinition of some polygons either through merging partially overlapping plots or by removing portions of the previously declared area. At the end of these processes of cleaning and removing overlaps, 1,474 polygons were removed (11.5% of the initial sample), resulting in a total of 11,349 polygons in Brazil representing *ABC Recuperação* credit operations conducted between 2016 and 2022.

The declaration of the polygons for the credit projects is part of the technical project preparation that the producer needs to present when seeking *ABC Recuperação* credit from financial institutions. This process is carried out together with accredited technical assistance from the bank, and there are internal validation mechanisms to ensure that the declared area matches the expected application of the credit resources. However, there may be errors in these declarations. For example, many of the declared polygons do not correspond entirely to pasture areas. In some cases, the entire property is being declared instead of just the pasture area to be recovered. To address this issue, estimates are also made considering only the pasture areas at the time of obtaining the credit, removing the polygon plots with other uses (such as crops and native vegetation). The results can be found in the "Sensitivity Analysis of Results" section at the end of the document.

20 Polygons can be obtained in two ways. SICOR/BCB's public rural credit microdata provides files with the coordinates of the glebae in WKT format and also the points (latitude and longitude) that make up these polygons through the "SICOR_GLEBAS" file. This work uses the first form. There may be occasional differences between the polygons constructed from the points and the finished polygons. Learn more at: BCB (ndd).

21 The circularity index is a measure that depends on the area and perimeter of the polygon, and is equal to one in perfect circles. The closer it is to zero, the more elongated the polygon. The cut-off line of 0.2 was defined as appropriate for the polygons in the analysis, generally removing polygons with implausible measurements such as more than 100,000 hectares in area or more than 50km between two points. This procedure uses the overlap resolution process carried out by land tenure of the Institute for Agricultural and Forest Management and Certification (*Instituto de Manejo e Certificação Florestal e Agrícola* - IMAFLORA) as a reference (Freitas et al. 2018).

Land Use Data and Pasture Quality

Land use and pasture quality data are obtained from MAPBIOMAS Collection 8.0 for the period 2000-2022. The vector information of the polygons is cross-referenced with information from satellite images (*raster*), obtaining the area of each type of land use within the polygon by weighting the intersection of the polygon with the cells (*grids*) of the image.[22]

This collection returns information on land cover and land use, including the area within the polygon covered by pasture, crop area, native forest, planted forest, among other categories. Because these classifications are obtained through a machine learning algorithm, some areas do not have a precisely assigned land use category, resulting in areas called “mosaic of uses”, such as the crop-cattle mosaic, which is an area that may predominantly be used for crops or pasture, but without a clear definition of which specific use is predominant (MAPBIOMAS 2023).

Pasture quality data were compiled by LAPIG (2022). To qualitatively assess the pastures, the land cover is classified as pasture using satellite images based on a machine learning model trained with visually inspected points. This pasture map is then cross-referenced with time series of Terra satellite images obtained from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor, which allows the vigor of pastures to be measured by calculating the Enhanced Vegetation Index (EVI). This index reflects color variations in the images that can be interpreted as measures of vegetation quality. These values are deseasonalized to minimize the impact of intra- and inter-annual seasonal variations on the data. To obtain the value for each year in each pixel, an annual average of the observed monthly medians is calculated. The indices are then normalized for each biome separately, resulting in a number ranging from 0 to 1, which is used to establish three categories:

- **Low quality** (index less than 0.4): pastures with signs of severe degradation;
- **Medium quality** (index between 0.4 and 0.6): pastures with signs of moderate degradation;
- **High quality** (index greater than 0.6): pastures with no signs of degradation.

Land use information is available for all the polygons observed in the SICOR/BCB data (11,349), but some polygons do not have corresponding pasture quality data because they did not have a pasture area in MAPBIOMAS in the period observed. The pairing results in 11,239 polygons with complete information on land use and pasture quality.

The pasture quality data represent the most comprehensive mapping available on the subject in Brazil. However, the data have some limitations. Firstly, the pixel size of the MODIS images is 250m by 250m, which represents an area of 6.25 hectares. This means that small polygons will have a potentially high measurement error, since it will not be possible to observe finer spatial variations in the type of land use. Even polygons slightly larger than the pixel size could still suffer the same problem. In any case, the average area of the polygons in the study sample is 160 hectares, and half of the distribution is above the median of 91 hectares, which is well above the pixel size. To test the robustness of the results regarding this issue, an exercise was conducted (reported in the “Sensitivity Analysis of the Results” section) by

22 For land use classes (and also secondary vegetation), the cross-referencing is done directly from the GeoTiff images downloaded from the MAPBIOMAS website (ndb). In the case of pasture quality data, the images are downloaded via the *Google Earth Engine* platform. Learn more at: bit.ly/49Pl96N.

cumulatively removing the initial deciles from the area distribution of the polygons in the sample, increasingly focusing on larger polygons, for which this problem will be smaller.

A second limitation relates to the quality of the information in each biome. The EVI indices serve as more accurate measures of pasture quality in the Cerrado compared to wetter biomes such as the Amazon and the Atlantic Forest. This is because pasture recovery processes can be more easily confused with native vegetation regeneration processes in wetter biomes (Dos Santos et al. 2022). For this reason, this study focuses on *ABC Recuperação* credit operations in the Cerrado biome. It is worth noting that one-third of Brazil's pastures are in this biome, which concentrates most of the hectares of pasture showing signs of degradation in the country. The biome is also responsible for around half of Brazil's meat production (Dos Santos et al. 2024). Additionally, more than half (52%) of the polygons in the credit sample (operations started between 2016 and 2022) are in the Cerrado. In terms of area, this percentage is 56%.[23] However, the study also presents results for all biomes in the "Sensitivity Analysis of Results" section.

A third limitation is that some recovery processes can qualitatively alter the pasture without necessarily changing the categories of pasture quality. The methodology used does not allow this type of change to be assessed. In general, the robustness tests carried out seek to mitigate some of the limitations of the data, providing greater reliability to the study's conclusions. Even so, future research could complement this analysis, either with more refined satellite images or by collecting data directly from the properties.

Other Information

In addition to data from the land use and pasture quality collections, data was also obtained from MAPBIOMAS' deforestation and secondary vegetation collection. Based on land cover and land use maps, this collection records transitions in satellite images to verify the suppression of primary vegetation and vegetation in the process of regeneration (secondary vegetation). This data is used in specifications where an attempt is made to control the results for the presence of secondary (recovering) vegetation to mitigate possible confusion with the recovery of pasture quality. The results are presented in the "Sensitivity Analysis of Results" section.

Finally, soil type data from the Brazilian Agricultural Research Corporation *(Empresa Brasileira de Pesquisa Agropecuária* - EMBRAPA) (2020) is used. This is vector data fixed in time (2020) showing the predominant soil type in each area in Brazil according to the Brazilian Soil Classification System (*Sistema Brasileiro de Classificação de Solos* - SIBCS). The map contains several levels of soil classification, but only the most aggregated level was considered in the analysis. It is worth noting that certain soil types may be more suitable for successful pasture recovery or for conversion to crops, suggesting that the results should vary according to the predominant soil type in each area (Sobrinho et al. 2021).

23 Even when considering all *ABC Recuperação* credit operations between 2016 and 2022, regardless of whether geodetic coordinates are observed or not, 49% are in municipalities whose predominant biome is the Cerrado. In terms of the amount of credit released, this percentage is 48%.

Methodology

The econometric methodology used to estimate the impact of *ABC Recuperação* credit is applied to the sample of polygons described in the previous section. In addition to focusing on the Cerrado, this study focuses on analyzing the effects of *ABC Recuperação* credit operations contracted between 2016 and 2018. As land use data is available until 2022,[24] the effects are observed in a window of four to six years after the credit is issued, which is a feasible interval for promoting pasture recovery (Zimmer et al. 2012). Furthermore, only polygons with a positive pasture area in MAPBIOMAS in the year of the credit operation are considered, ensuring that there is pasture to be recovered or converted. With these restrictions, the methodology is applied to a sample of 2,239 polygons observed over 23 years (2000-2022), resulting in 51,497 polygon-year observations.

Simply comparing the results between the periods before and after the release of *ABC Recuperação* credit cannot be interpreted as an estimate of the policy's causal effect. The main source of bias in this comparison is related to the existing previous trend. For example, the polygons might have already been on a pasture recovery trajectory before the credit was granted, and this trajectory only continued in the following period. Additionally, borrowers may have already been on a path of converting pasture to other uses before the credit was granted. To identify whether the credit actually had any effect, it is necessary to identify comparison groups that show similar previous trends, so that any difference between these trends after the release of the funds can be attributed to the granting of the credit.

To find a causal estimate of the impact of credit, the timing of the operation is explored, comparing polygons that contract credit in one period (say, t) with those that contract credit in a subsequent period (say, $t + 1$). In this way, units treated in subsequent periods act as controls for units treated at a certain point in time.

One advantage of this approach is that it does not use polygons on properties that do not receive credit for pasture recovery as a control, which minimizes the problem of selection bias. This problem would arise from the fact that properties that take out this type of credit differ in several characteristics (observable or not) from properties that take out other types of credit or that do not take out credit, which could explain any differences observed between the two groups. A disadvantage is that, when exploring timing as a source of variation in the data, considering that only three years of credit operations are used (2016 to 2018), there is a limitation to controlling for specific issues of each year that could affect all polygons similarly (year fixed effect). The inclusion of the year fixed effect competes with the relevant variation

24 Up to the time of publication of this report (August 2024).

that this approach exploits. This problem is mitigated by using linear time trends, as will be explained below.[25]

In the empirical strategy, a panel linear regression is estimated using Ordinary Least Squares (OLS) as in equation (1):

$$y_{it} = \beta D_{it} + \alpha_i + t + X_{it} + \varepsilon_{it}$$

This model is indexed by polygons i of *ABC Recuperação* credit operations and years t of observation of land use variables.[26] y_{it} identifies the results of interest, expressed as percentages of the polygon area, such as the percentage of the polygon area covered by pasture and the percentage of each quality class. D_{it} is an indicator variable equal to 1 from the year in which the polygon receives credit, and zero otherwise, so that β is the coefficient of interest, which captures the average effect of *ABC Recuperação* credit on the variables y_{it} always expressed in percentage points (p.p.). α_i is the polygon fixed effect, which controls for all the characteristics of polygons that do not vary over time. t is a linear time trend, which seeks to control for factors that vary over the years and which affect all polygons similarly, as long as they are linear in time. X_{it} is a set of additional controls included in the regression for robustness, such as the percentage of secondary vegetation area in the polygon, specific linear time trends by predominant soil type in the polygon and specific time trends by land use classes at the start of the period (2000). These controls are not used in the main specification, but the results controlling for these factors are presented at the end of the document, in the "Sensitivity Analysis of Results" section. ε_{it} is the error term of the regression. The regression is weighted by the area of the polygon, so that the coefficient reflects the effect on an average polygon. Finally, the standard errors are clustered by predominant soil type, taking into account that unobservable factors that could explain the results are potentially correlated within the areas where each soil type predominates, a determining factor for the pasture recovery process.

This regression captures the average effect taking into account the entire period after taking out the loan, which varies from four to six years depending on the year of the operation. However, it is possible to capture the dynamic effect—i.e., the effect in each year after taking out the loan—using an event study approach. This approach makes it possible to identify trends in the effects of borrowing and visually test the validity of the hypothesis of similar previous trends. The regression has the format shown in equation (2):

$$y_{it} = \sum_k \beta_k \,.\, I\{t - E_i = K\} + \alpha_i + t + X_{it} + \varepsilon_{it}$$

In this specification, $I\{t - E_i = K\}$ indicates the number of periods K relative to the year of the credit operation E_i for each polygon. In other words, β_0 captures the effect in the year of the credit operation, β_1 captures the effect one year after the credit, and so on. Additionally, the β_k for $K < 0$ are estimated, which capture previous trends. These estimated coefficients are expected to be zero, as this suggests that there are no distinct prior trends between the

25 Another limitation is that the results of this study do not allow the effect on avoided degradation to be estimated. For example, if there were a group of untreated polygons comparable to the group of polygons receiving *ABC Recuperação* credit and this group observed an increase in degradation over time, the estimated effect of the credit would potentially be greater, capturing the fact that the presence of the credit would prevent an increase in degradation. However, the overall picture of pasture degradation in Brazil suggests that this is not the case: on average, with the exception of the two most recent years (2021 and 2022), Brazilian pastures have been on a trajectory of decreasing rather than increasing degradation. This suggests that an estimate with an untreated comparison group would tend to generate similar results to those of this study, but at the additional cost of dealing with a series of selection biases. An impact analysis with an untreated group could be the subject of future research.

26 In this case, the calendar year is used. The agricultural year (which is normally used for rural credit analysis) is not used because MAPBIOMAS data is aggregated by calendar year.

comparison groups. The results of the event studies are be presented in the form of graphs, so that, visually, it is expected that, before the credit, the graph will be a straight line close to zero, which allows inferences about the trend after the credit. The graphs are be truncated up to four years after the credit operation, in order to ensure that the same sample of polygons is observed in all four years.

Evaluation of Assessment *ABC Recuperação* Credit

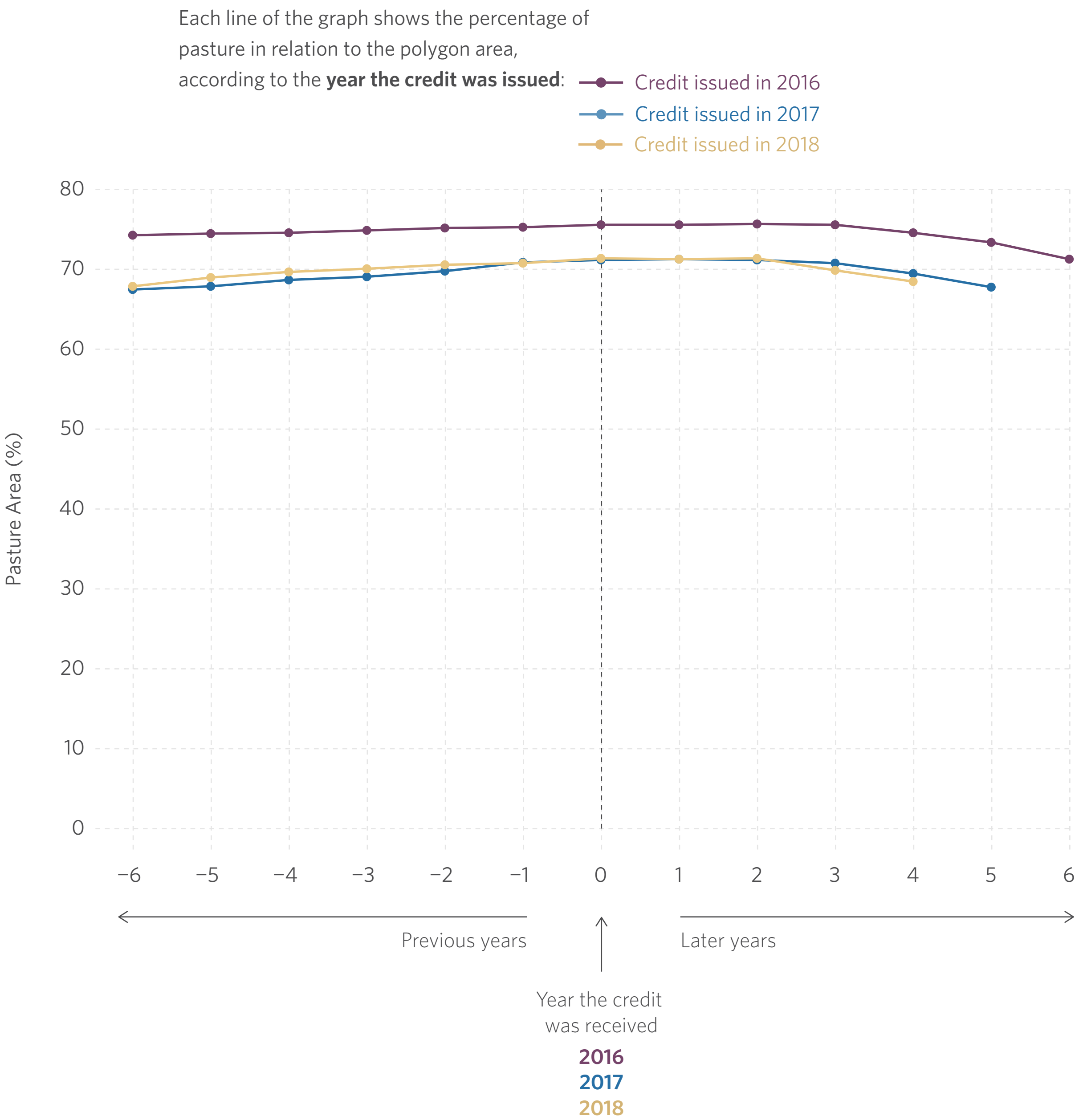
Descriptive Statistics

As expected, the polygons declared for pasture recovery projects are predominantly composed of pasture. However, several polygons also contain areas designated for other uses such as crops and native forest. In the period before the credit was issued, the average percentage of pasture within these polygons varied from 67% to 75% depending on the year the credit was issued out.

After taking out the credit, there is no significant change in the predominant land use within these enterprises. A slight decrease in pasture area begins to occur about three years after the credit is issued. However, this decrease is marginal, with a maximum reduction of 4 p.p. observed in the polygons of operations initiated in 2016, and tracked six years after the credit issuance. This data is presented in **Figure 5**, which shows the percentage of pasture relative to the total area of the polygons, according to the year the *ABC Recuperação* credit was contracted, marking the moment as the year the funds were released.

The data indicates that these pasture areas exhibited strong signs of degradation before the credit was contracted. Before the funds were released, between 71% and 78% of the pasture fell into the low or medium vigor categories, reflecting that 49% to 58% of the polygon area was covered by pasture showing signs of degradation.

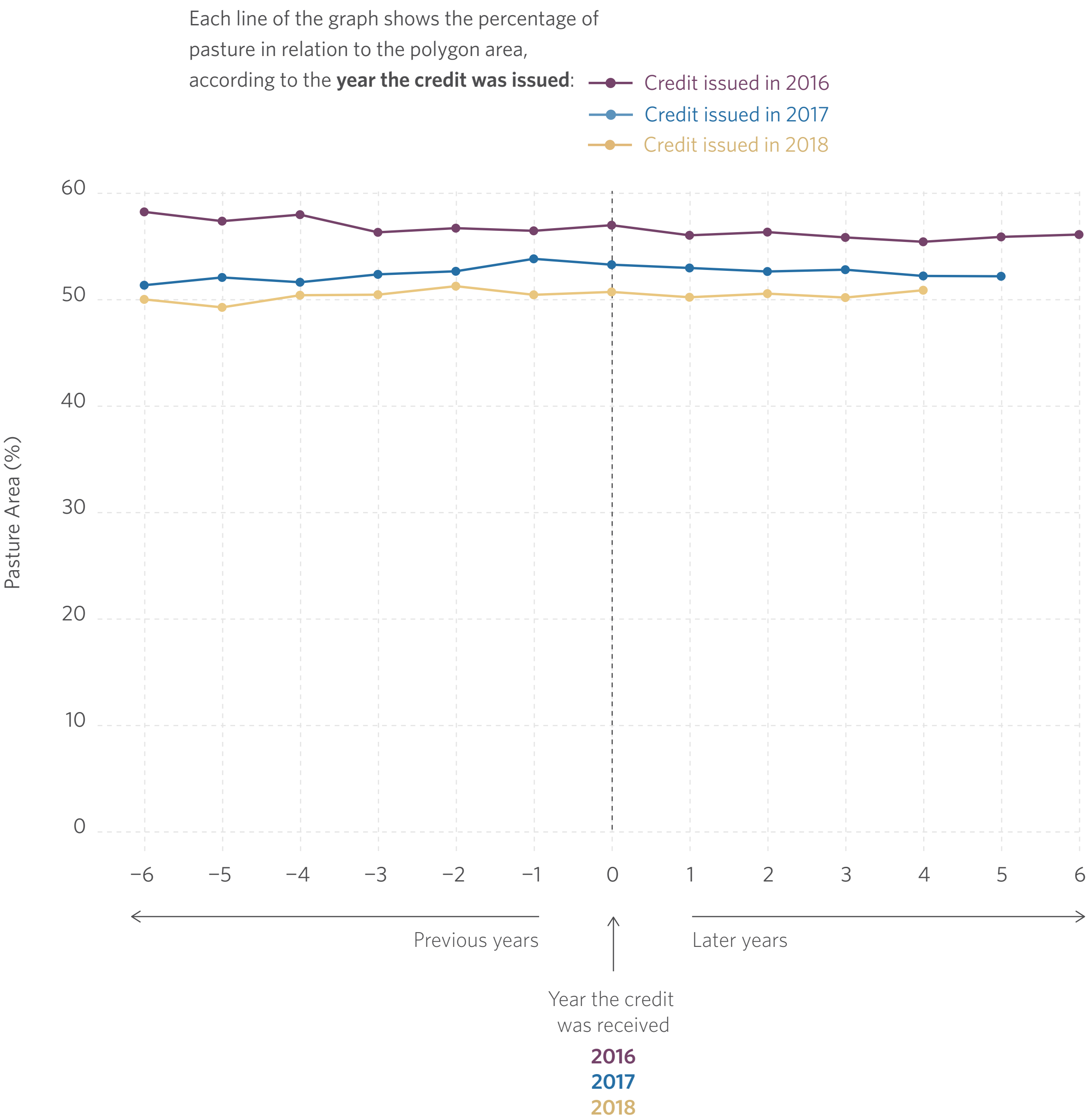
Figure 5. Percentage of Pasture Areas over the Total Area of *ABC Recuperação* Credit Polygons in the Cerrado, Operations Contracted between 2016–2018



Source: *CPI/PUC-RIO with data from SICOR/BCB (2024) and LAPIG/MAPBIOMAS (2022), 2024*

However, the trajectory of degradation remains largely unchanged after the credit is granted. The changes amount to a maximum average reduction of 1.6 p.p. in the proportion of low or medium quality pastures five years after the resources were released, considering the polygons whose operations began in 2017, as shown in **Figure 6**.

Figure 6. Percentage of Low or Medium Quality Pastures over the Total Area of *ABC Recuperação* Credit Polygons in the Cerrado, Operations Contracted between 2016–2018

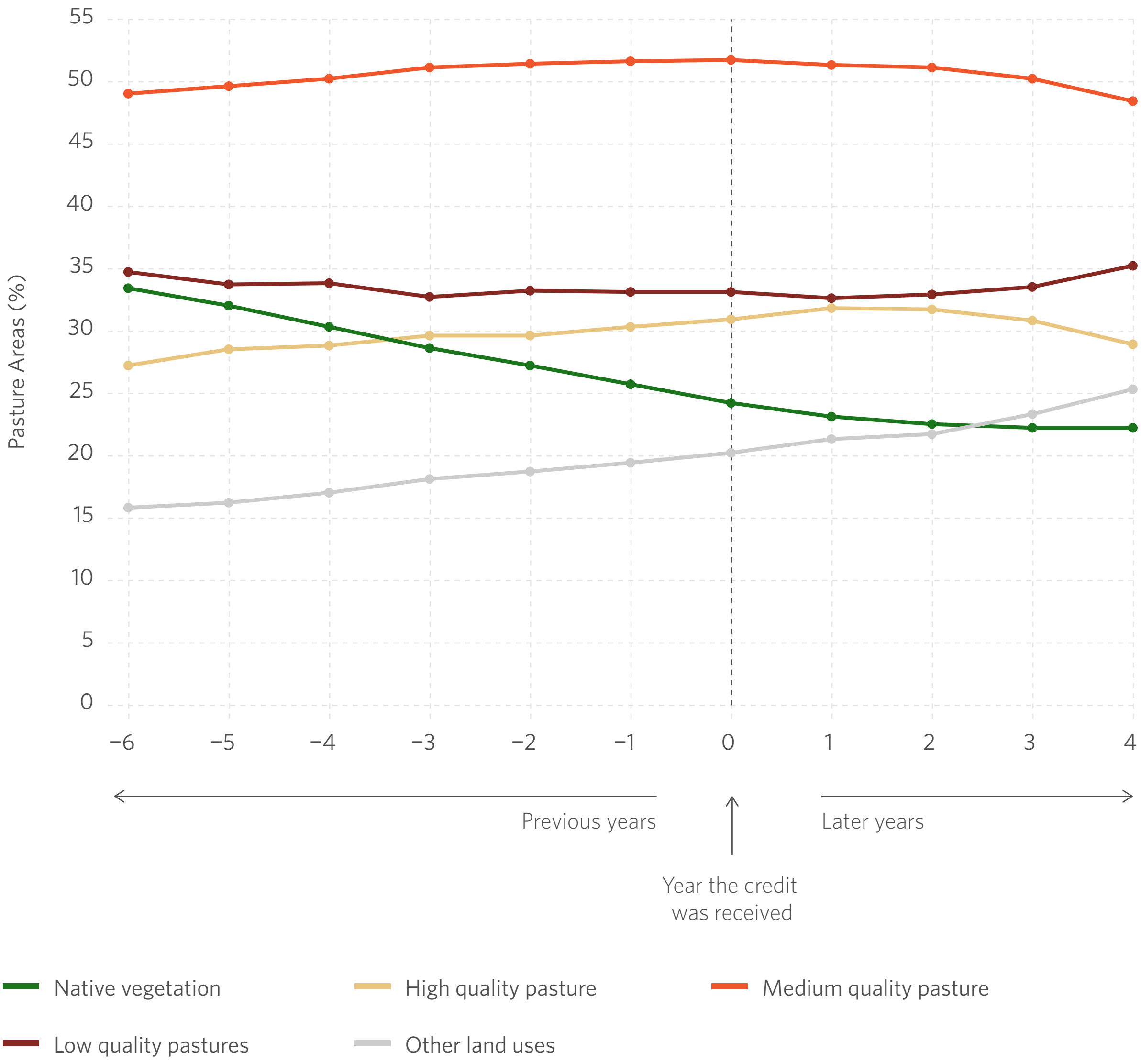


Source: *CPI/PUC-RIO with data from SICOR/BCB (2024) and LAPIG/MAPBIOMAS (2022), 2024*

At least a portion of the areas declared to receive financing for pasture recovery had been deforested in the years immediately prior to taking out the credit. **Figure 7** shows average pasture areas in hectares by land use category: low, medium and high-quality pastures, native vegetation (forest and non-forest), and other uses (which include crops and the crop-cattle mosaic). With an average polygon of 160 hectares, in the years before the credit was issued there was a tendency for native forest areas (-7.7 ha, corresponding to 4.8 p.p. of the total area) to be replaced by pasture (+4.1 ha or 2.6 p.p.) and other uses (+3.6 ha or 2.2 p.p.). The observed increase in pasture area comes mainly from areas of medium and high quality.

In the period after the credit was issued, the deforestation trend slowed down and there was some conversion of pasture to other uses. Pasture areas are subtly reduced, but there is a small increase in low quality areas, especially three years after taking out the credit, as opposed to a decrease in high quality areas.

Figure 7. Average Pasture Area by Quality Class, Native Vegetation and Other Land Uses of *ABC Recuperação* Credit Polygons in the Cerrado, Operations Contracted between 2016–2018

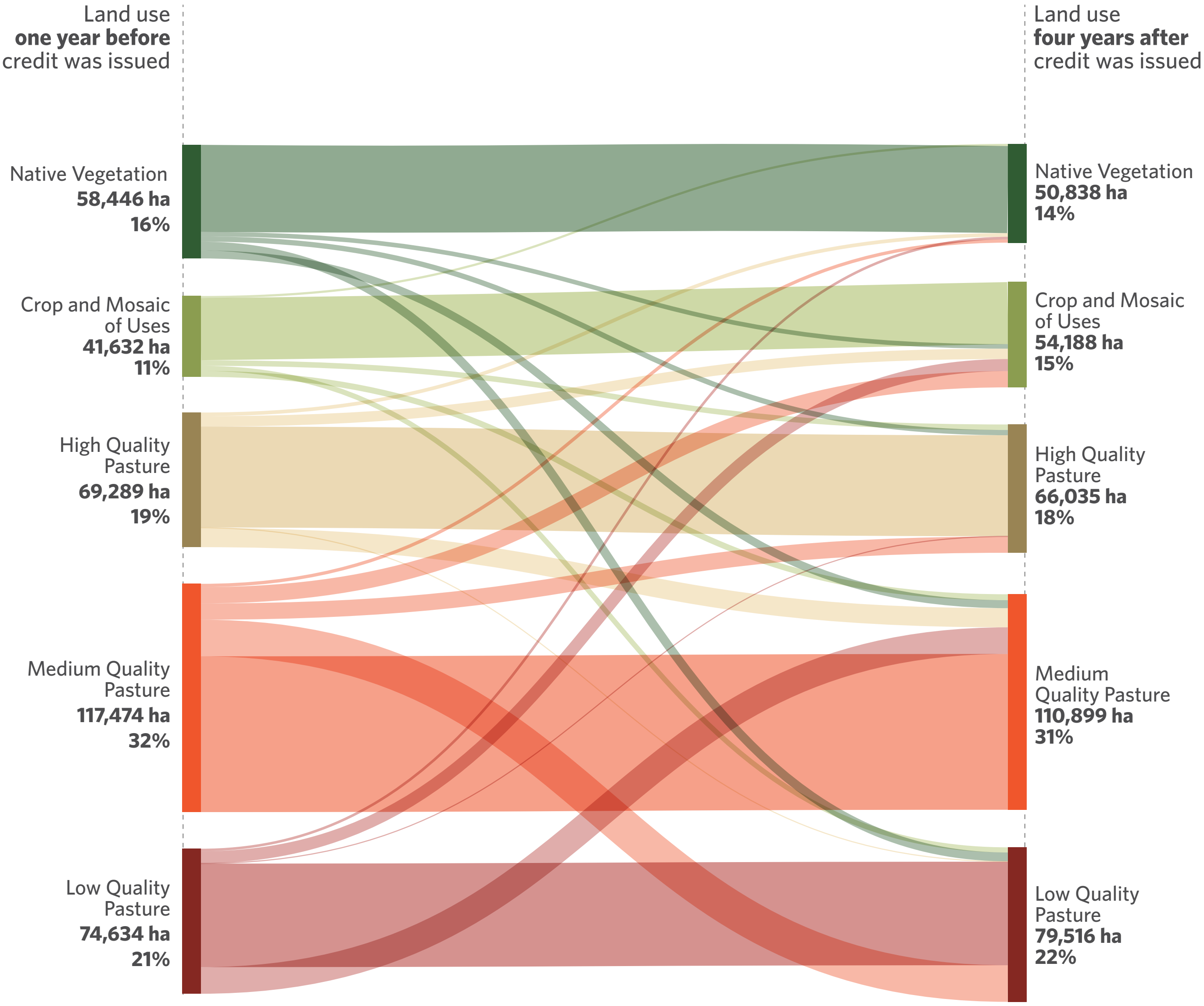


Source: *CPI/PUC-RIO with data from SICOR/BCB (2024) and LAPIG/MAPBIOMAS (2022), 2024*

Analyzing the data as a proportion of the area of the polygons does not allow us to understand the type of transition that occurs in these areas. To complement this analysis, pixel-by-pixel transitions from MAPBIOMAS satellite images are examined, focusing on the portions of these pixels that intersect with the analyzed polygons. **Figure 8** shows the distribution of area by land use class and pasture area quality. The left side of the graph presents the land use status one year before the credit was released, while the right-hand side shows the changes that occurred four years after the credit was issued.

The analysis indicates that most of these areas remained unchanged over the period analyzed, with 72.5% of the total polygon area maintaining the same land use or pasture area class. From an aggregate perspective, the recovery of degraded pastures in some areas was partially offset by a decline in quality in other areas. Only 6.2% of the total pasture area consists of pastures that have improved in vigor (transitioning from low to medium quality, or from low/medium to high quality), and another 5.5% are pastures converted into crops or a mosaic of uses. However, another 8.0% of the pasture area shows a decline in quality (high/medium to low or high to medium quality). Additionally, the conversion of native vegetation into crops or pasture represents 3.8% of the area.

Figure 8. Land Use Transitions in *ABC Recuperação* Credit Polygons in the Cerrado, Operations Contracted between 2016–2018



Note: *The category "Crop and mosaic of uses" includes different types of crops, planted forests and crop-cattle mosaic areas, which are not distinguishable between crops and pastures. The "Native Vegetation" category includes natural forest and non-forest formations. Transitions involving non-vegetated areas and bodies of water are very small and are therefore not shown on the graphic.*
Source: *CPI/PUC-RIO with data from SICOR/BCB (2024) and LAPIG/MAPBIOMAS (2022), 2024*

Descriptively, the areas declared to receive credit for pasture recovery have shown few changes. On a small scale, reductions in deforestation pressure, slight recoveries in pasture health, and conversions of pasture to crops are observed, but also new processes of pasture degradation. Based on this evidence, the application of econometric methodology aims to estimate the causal effect of *ABC Recuperação* credit, controlling for various factors that could explain the patterns observed.

Results of the Empirical Analysis

Average Effects

The estimation of equation (1), which analyzes the percentage of pasture within the polygon area and its breakdown by pasture quality classes, supports the descriptive findings: the impacts observed in the areas receiving *ABC Recuperação* credit are modest. On average, the provision of credit for pasture recovery is associated with a statistically significant reduction of 3 p.p. in the pasture area of the polygon, as shown in **Table 1**. For an average-sized polygon of 160-hectares, this corresponds to less than five hectares of pasture per polygon being converted over a period of four to six years.

When analyzing pasture areas by quality class, there was a reduction in the area of medium and high quality pastures by 2.6 p.p. and 1.8 p.p., respectively. This trend suggests that the conversion of pasture to other uses occurs predominantly in pasture areas with fewer signs of degradation, or that the process of pasture recovery precedes conversion to some extent. Additionally, there is no reduction in low quality pastures, which exhibit the most severe signs of degradation. The coefficient for these areas is positive, but not statistically significant. This result suggests that borrowers may be choosing areas with lower recovery costs to promote conversion to other uses.

Table 1. Average Effects of *ABC Recuperação* Credit on Various Variables of Interest (Percentages of Polygon Area), Credit Operations Carried Out between 2016 and 2018 in the Cerrado

	Pasture (%)	Low quality pasture (%)	Medium quality pasture (%)	High quality pasture (%)	Farming (%)	Soybean crops (%)	Other temporary crops (%)	Crop-cattle mosaic (%)	Natural forest (%)	Planted forest (%)	Non-forest native vegetation (%)
Effect of *ABC Recuperação* credit	-2.97** (0.78)	1.45 (0.79)	-2.60*** (0.55)	-1.82*** (0.41)	0.98* (0.45)	0.86* (0.40)	0.38 (0.37)	1.09*** (0.19)	0.92 (0.50)	-0.03 (0.03)	-0.10 (0.13)

Note: *Effects estimated from equation (1) with the specification without additional controls (only polygon and linear time trend fixed effects). Coefficients expressed in percentage points. Standard errors clustered by predominant soil type in the polygon in parentheses. Statistical significance levels: *** p-value less than 0.01; ** p-value less than 0.05; * p-value less than 0.1. The crop-cattle mosaic is an undefined area between crop and pasture.*
Source: *CPI/PUC-RIO with data from SICOR/BCB (2022), LAPIG/MAPBIMAS (2024), and EMBRAPA (2020), 2024*

There is evidence that at least part of this pasture is being converted to crops, although the estimated effects are small. **Table 1** shows a significant increase of 1 p.p. in the percentage of crop area in the polygons, predominantly attributed to soybean cultivation. There is also a positive coefficient for other temporary crops and a positive and significant increase of 1.1 p.p. for the crop-cattle mosaic, which corresponds to areas where there is no precise identification between crops and pasture areas. Even assuming that all of this mosaic area corresponds to crops, these effects would still not fully explain the portion of the polygons converted to other uses.

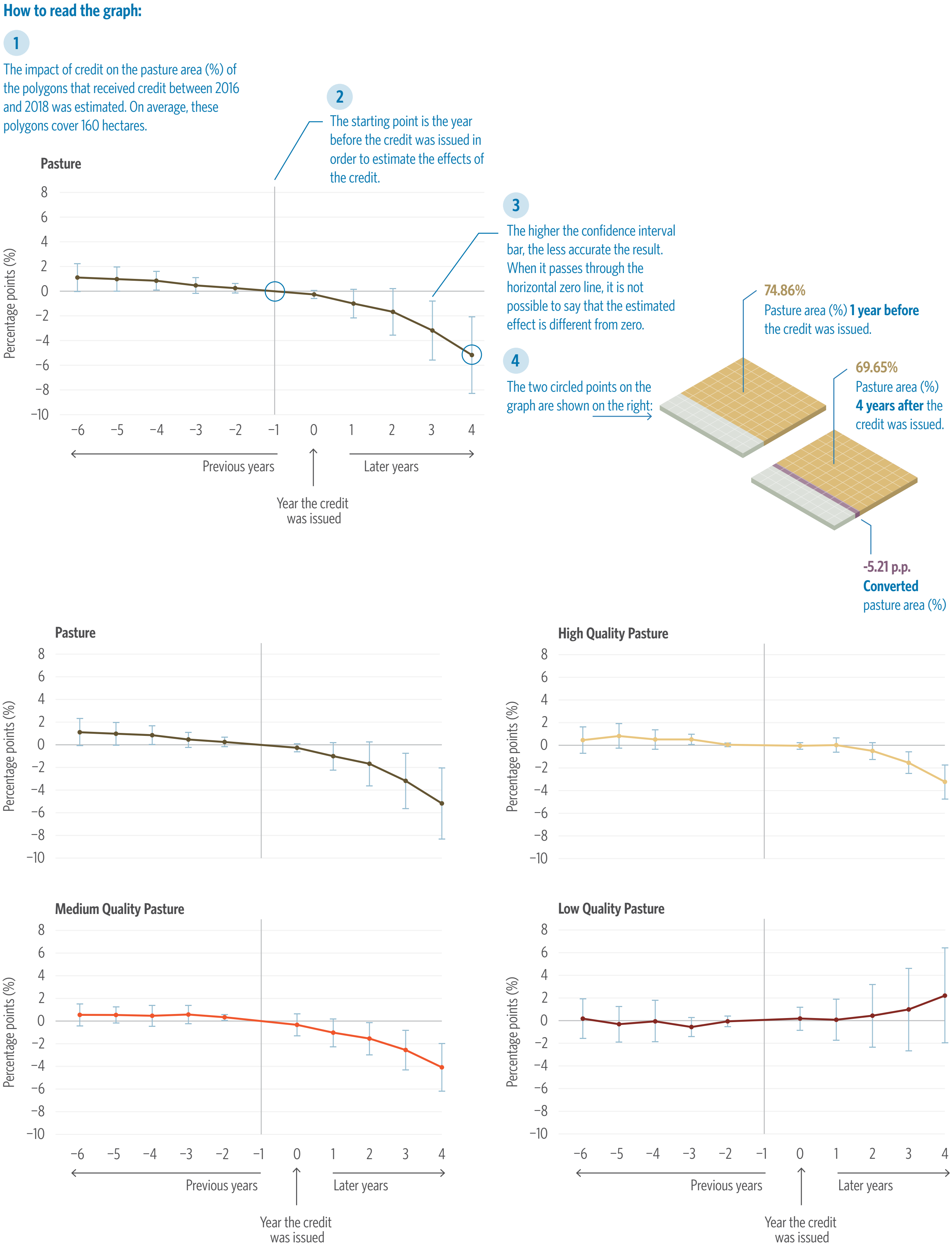
It is possible that part of the effect of the *ABC Recuperação* credit stems from a reduction in deforestation after the credit was issued. While not statistically significant, the coefficient for native forest area within the polygon is positive, as shown in **Table 1**. However, this positive coefficient does not necessarily indicate an increase in forest areas in the polygon, since it is derived from comparing areas that received credit at different times. In fact, these areas were previously converted from native vegetation to pasture before receiving the credit. Therefore, the coefficient may just be capturing the fact that deforestation decreases after taking out the credit, used in the newly converted pasture area. The magnitude of this effect, which is also very small (0.9 p.p.), is compatible with the difference between the reduction in pasture area and the increase in crop and crop-cattle mosaic areas. Furthermore, there is no effect for the areas of planted forest and non-forest native vegetation.

Effects Over Time

The estimation of equation (2) enables an analysis of how the average effects presented in the previous section vary each year after the credit is released, revealing trends. It also facilitates a visual inspection to validate the hypothesis that there were no prior trends before the credit issuance, which is essential for attributing causality to the estimated coefficients. As can be seen below, all the figures show pre-credit release coefficients equal to or very close to zero, with confidence intervals that do not allow the hypothesis that they are effectively zero to be rejected.

All observed effects demonstrate an increasing trend over time, likely reflecting the maturation of investments. However, even four years after the funds were disbursed, the effects remain modest. The effects observed for pasture indicate that the more time that passes after the credit is issued, the greater the share of the polygon area that is converted from pasture to other uses. As **Figure 9** shows, this shift becomes more pronounced starting three years after the funds are released. Even four years after taking out the credit, the reduction observed is just over 5 p.p. This conversion primarily affects pastures of high and medium quality. Low quality pastures, on the other hand, remained practically unchanged, with non-statistically significant changes.

Figure 9. Effects of *ABC Recuperação* Credit on the Proportion of Total Pasture Area and by Quality Classes over the Polygon Area, 2016–2018

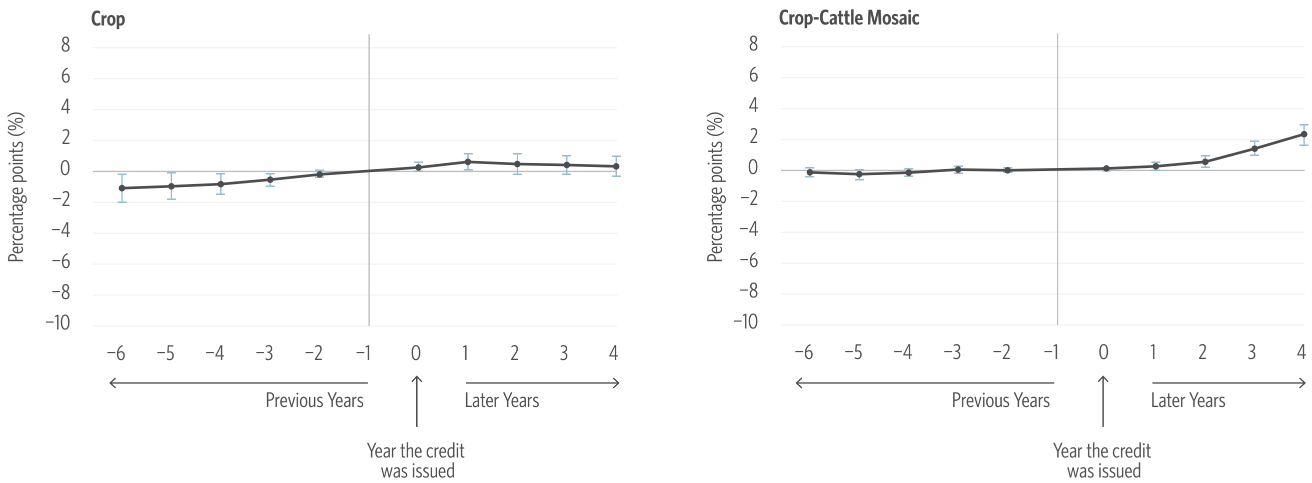


Note: *Effects estimated from the equation (2) without additional controls (only polygon and linear time trend fixed effects). Coefficients expressed in percentage points. Standard errors clustered by predominant soil type in the polygon. Confidence intervals at 95% significance level.*
Source: *CPI/PUC-RIO with data from SICOR/BCB (2022), LAPIG/MAPBIOMAS (2024) and EMBRAPA (2020), 2024*

As seen in the estimation of average effects, part of this pasture area is converted to other uses. However, the dynamic estimates do not offer a detailed understanding of the changes occuring in these areas. As shown in **Figure 10**, the dynamic effects on the crop area are hampered by a slight pre-existing trend before credit was issued. In contrast, the area of crop-cattle mosaic increases significantly, exceeding 2 p.p. four years after the funds were disbursed.

Although the effects observed are minimal, it is evident that there is some transformation of land use within a small portion of the polygons, but the available data do not allow for a qualitative understanding of these transformations. Some hypotheses are 1) adoption of integrated crop-cattle systems; 2) crop rotation with forage crops; and 3) conversion to crop uses not captured by the satellite during the period analyzed.

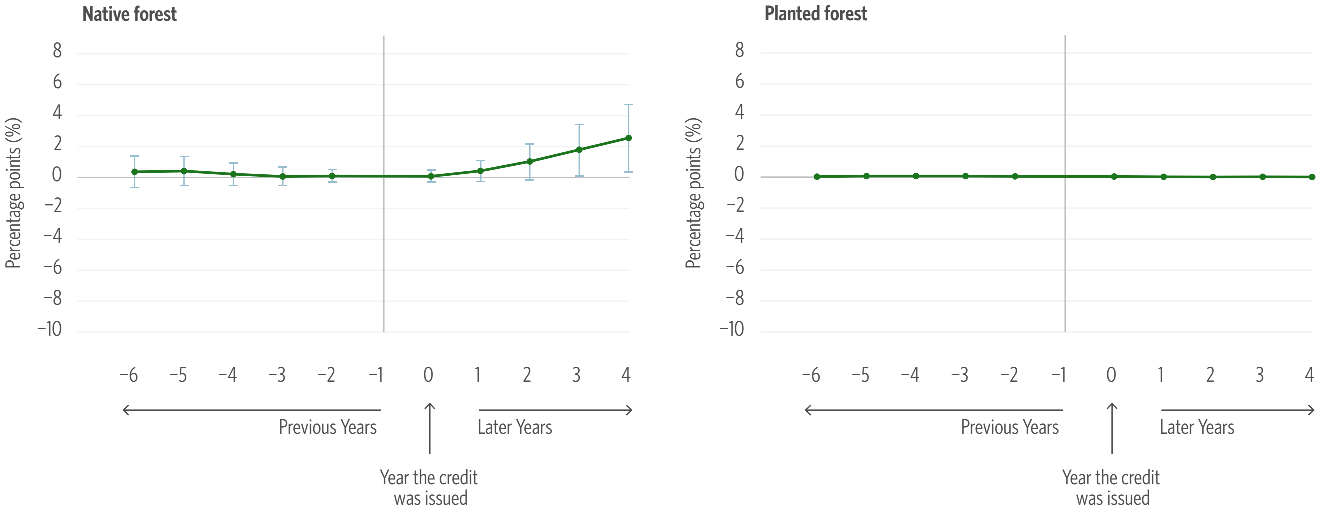
Figure 10. Dynamic Effects of *ABC Recuperação* Credit on the Proportion of Crop Area and Crop-Cattle Mosaic over the Polygon Area, 2016–2018



Note: *Effects estimated from the equation (2) with the specification without additional controls (only polygon and linear time trend fixed effects). Coefficients expressed in percentage points. Standard errors clustered by predominant soil type in the polygon. Confidence intervals at 95% significance level. The crop-cattle mosaic is an undefined area between crop and pasture.*
Source: *CPI/PUC-RIO with data from SICOR/BCB (2022), LAPIG/MAPBIOMAS (2024) and EMBRAPA (2020), 2024*

The reduction in deforestation after taking out the credit is more apparent in the analysis of the dynamic effects, although the coefficients are still low in magnitude. As shown in **Figure 11**, areas that receive *ABC Recuperação* credit show approximately 2.5 p.p. less deforestation in native forest areas four years after the funds are disbursed. This effect likely relates to the observed deforestation and conversion to pasture prior to the credit issuance. No significant trends were observed in the case of planted forests.

Figure 11. Dynamic Effects of *ABC Recuperação* Credit on the Proportion of Natural Forest and Planted Forest Area over the Polygon Area, 2016–2018



Note: *Effects estimated from the equation (2) with the specification without additional controls (only polygon and linear time trend fixed effects). Coefficients expressed in percentage points. Standard errors clustered by predominant soil type in the polygon. Confidence intervals at the 95% significance level.*
Source: *CPI/PUC-RIO with data from SICOR/BCB (2022), LAPIG/MAPBIOMAS (2024) and EMBRAPA (2020), 2024*

Heterogeneous Effects

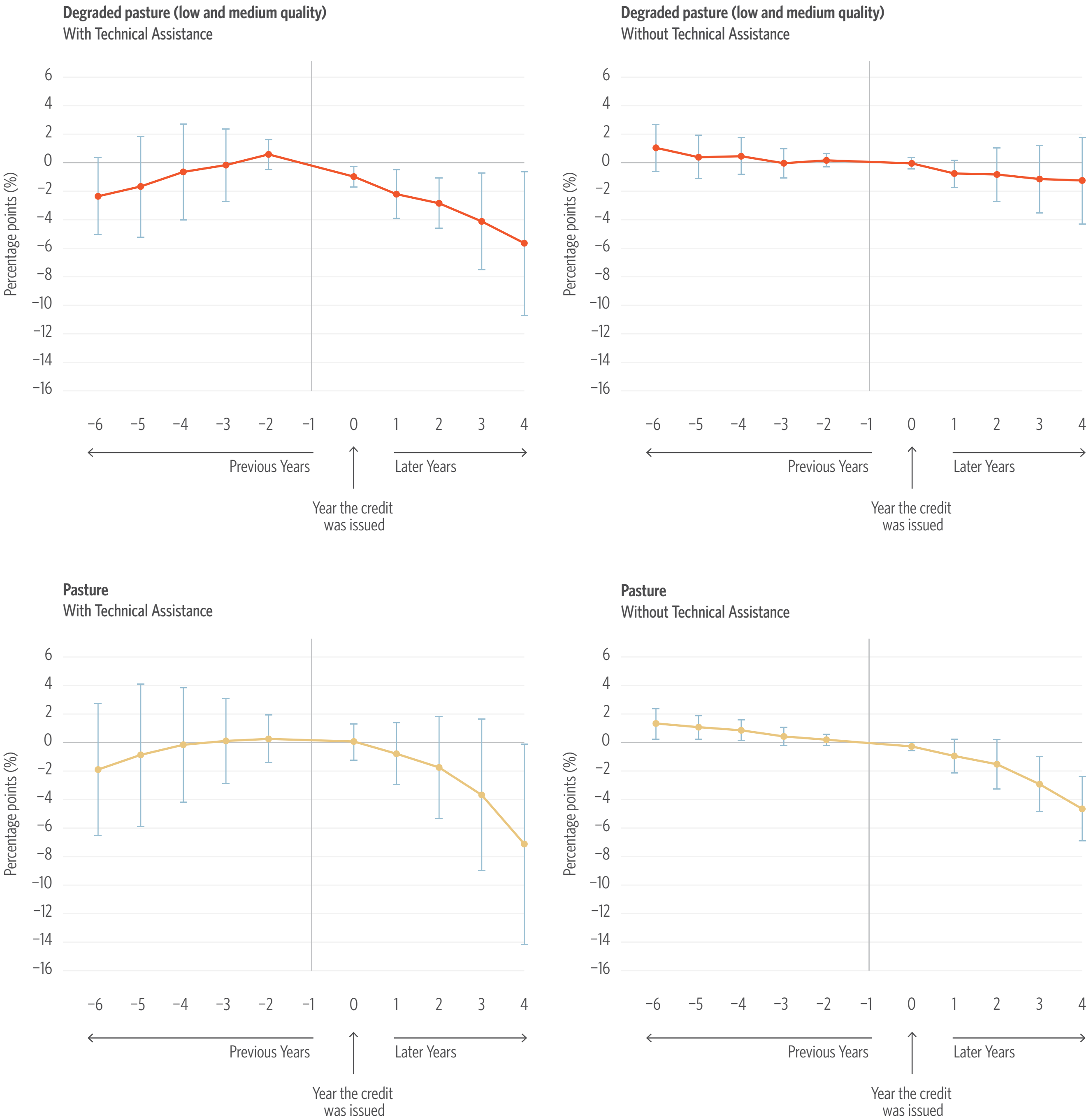
The effects observed vary based on specific characteristics of the polygons and the nature of the credit operations. This section evaluates key areas of heterogeneity that influence the outcomes, such as the contracting of technical assistance and the predominant soil type in the polygon.

Regarding technical assistance, borrowers can allocate a portion of the *ABC Recuperação* credit to hire technical advice for implementing the technical project presented to obtain the credit.[27] Of the polygons in the study sample, 480 (21.4%) are associated with contracts that include technical assistance, while 1,759 (78.6%) do not have this attribute. Consequently, the analysis of the program's effects can be conducted separately for each group to observe potential differences.

Technical assistance is a key factor in the recovery of degraded pastures, though it has less influence on the conversion of pastures, as shown in **Figure 12**. For contracts with technical assistance, there is a statistically significant reduction in area of low or medium quality pasture, reaching a reduction of almost 6 p.p. four years after taking out the credit. Meanwhile, the trend for polygons without the service is practically unchanged. While the overall trajectory of conversion from pasture to other uses is similar for both groups, the smaller sample size for those with technical assistance leads to larger standard errors, rendering the coefficients not statistically significant. These findings indicate that producers who invest credit resources in technical assistance are better able to rehabilitate pastures that are more severely degraded, although the magnitude of these effects is still modest.

27 For the same contract (*ref_bacen*) in SICOR, it is possible to identify operations (*ref_bacen* + *nu_ordem*) that contain the activity "Provision of Technical and Business Advice; Consultancy and Preparation of projects and training" in the "Product" field.

Figure 12. Dynamic Effects of *ABC Recuperação* Credit on the Proportion of Total Pasture Area and Degraded Pasture (Low or Medium Quality) over the Polygon Area, with and without Technical Assistance, 2016–2018



Note: *Effects estimated from the equation (2) with the specification without additional controls (only polygon and linear time trend fixed effects). Coefficients expressed in percentage points. Standard errors clustered by predominant sun type in the polygon. Confidence intervals at the 95% significance level.*
Source: *CPI/PUC-RIO with data from SICOR/BCB (2022), LAPIG/MAPBIOMAS (2024) and EMBRAPA (2020), 2024*

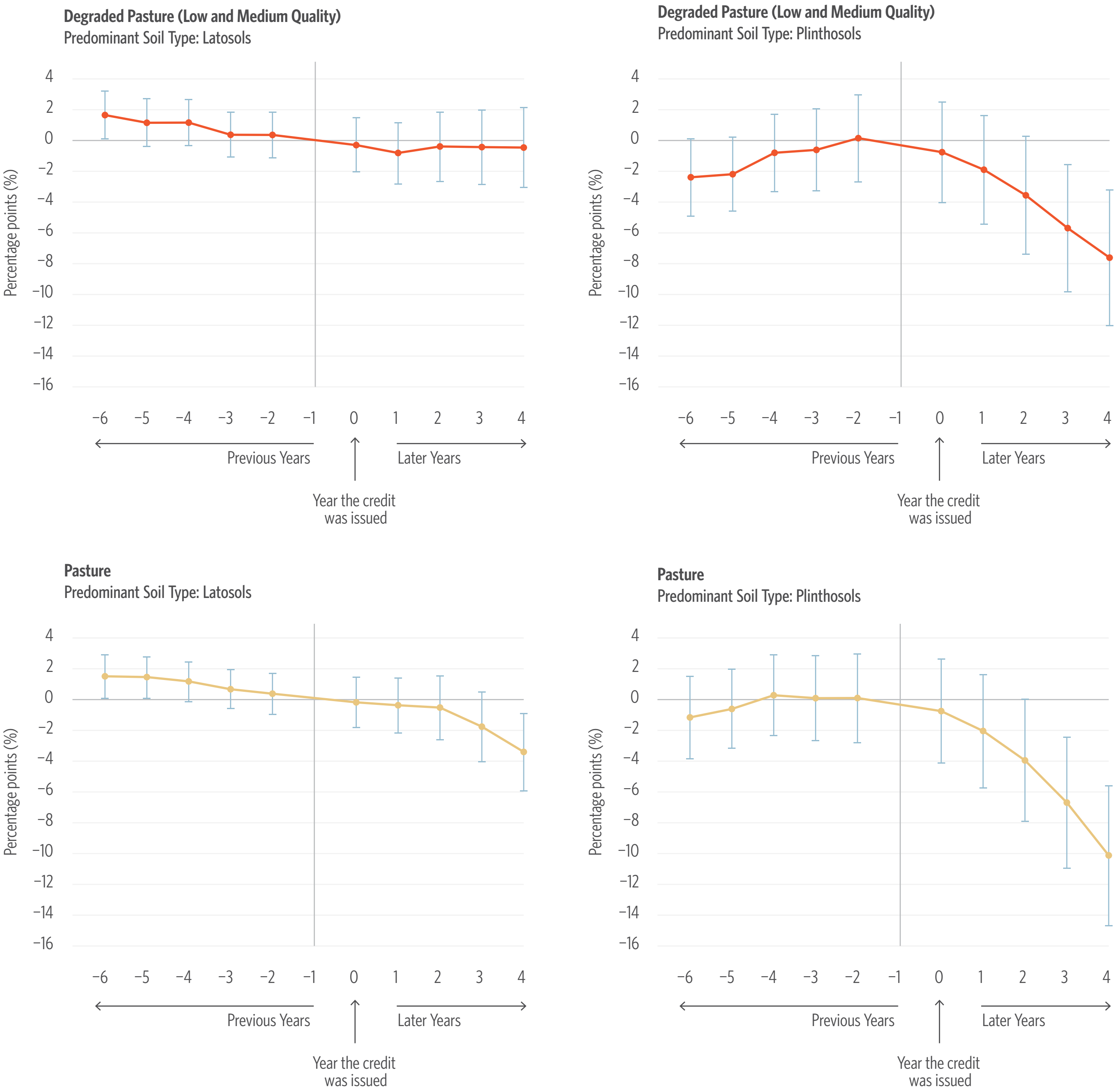
Borrowers who choose to hire technical assistance differ from those who do not across several dimensions, which may partly account for the observed results. Typically, it is expected, that producers who hire technical assistance are larger and have a greater capacity to mobilize resources. However, the data present a contrasting picture: contracts with technical assistance have a slightly lower average value (R$672,000) compared to those without (R$709,000). Additionally, the average area of polygons in operations with technical assistance (98 ha) is smaller than in operations without (177 ha).

These findings align with other studies by CPI/PUC-RIO researchers who point out that training and assisting producers to implement techniques for recovering degraded pastures are critical to the success of the operation (Bragança et al. 2022), especially for smaller producers (Souza et al. 2022).

The success of the pasture recovery process is anticipated to depend on the predominant soil type at each location. According to EMBRAPA data, the majority of the polygons in the study sample (42%) are in areas where Latosols predominate. These are followed by Acrisols (16.8%), Plinthosolos (15.7%), Cambisols (12.3%) and Neosols (10.1%). Other soil types predominate in a very small number of polygons (3.1%).

The results by soil type indicate that polygons predominated by P linthosols experience a more significant impact of credit on pasture recovery and conversion. **Figure 13** shows the dynamic coefficients for degraded and total pastures, comparing the most prevalent soil type (Latosols) with Plithosols. The coefficients in the Plinthosol areas reach almost 8 p.p. of recovered area four years after the credit (reduction of low or medium quality pasture) and 10 p.p. of converted area, a magnitude that is higher than all the results found for the complete sample. The polygons in areas where the most frequent type of soil predominates (Latosols) do not observe any change in the trajectory of degraded pastures and observe a conversion of less than 4 p.p. from pasture to other uses.

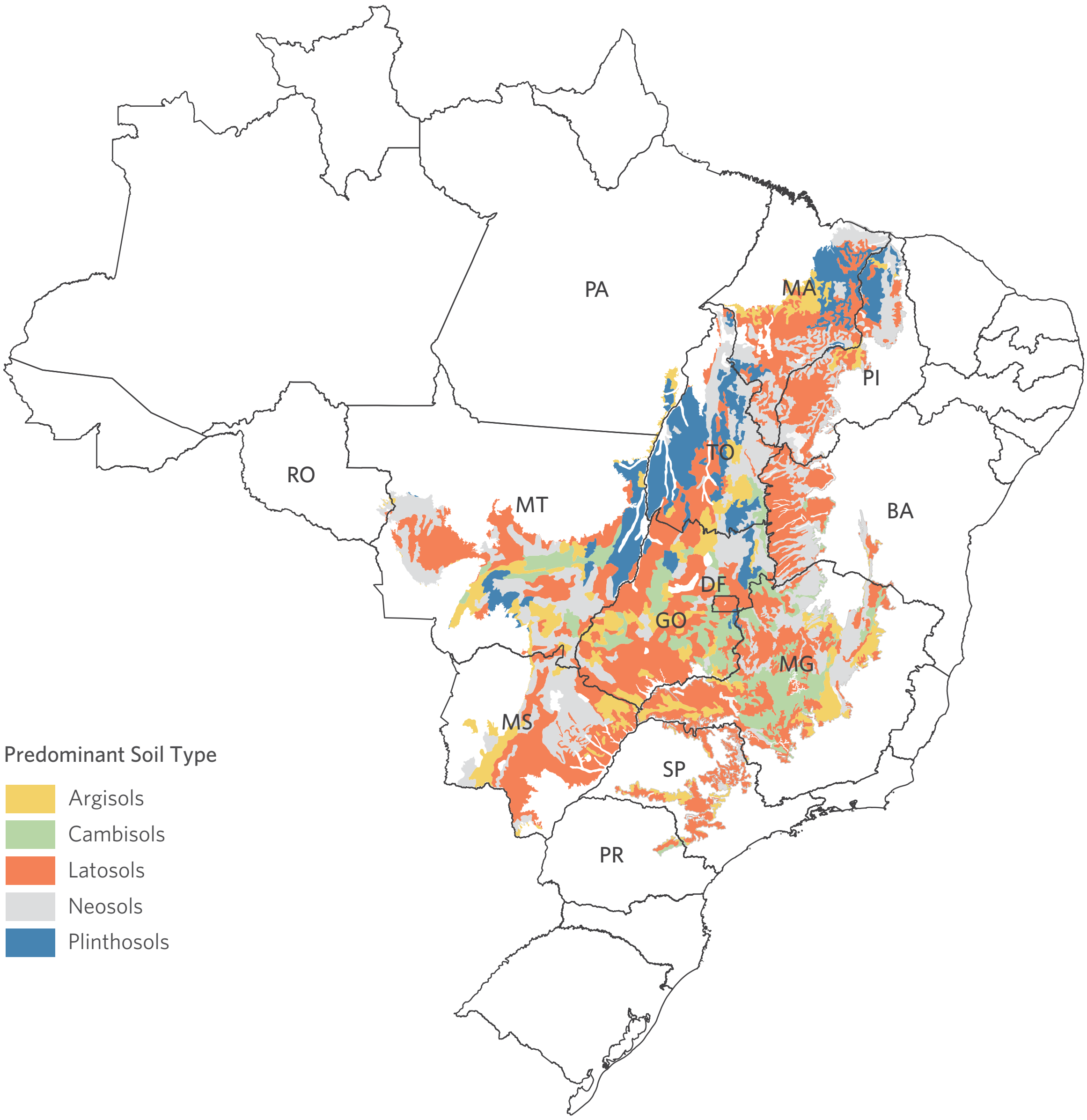
Figure 13. Dynamic Effects of *ABC Recuperação* Credit on the Proportion of Total Pasture Area and Degraded Pasture (Low or Medium Quality) over the Polygon Area, for Different Soil Types, 2016–2018



Note: *Effects estimated from the equation (2) with the specification without additional controls (only polygon and linear time trend fixed effects). Coefficients expressed in percentage points. Standard errors clustered by predominant sun type in the polygon. Confidence intervals at the 95% significance level.*
Source: *CPI/PUC-RIO with data from SICOR/BCB (2022), LAPIG/MAPBIOMAS (2024) and EMBRAPA (2020), 2024*

While the Latosols are practically scattered throughout the Cerrado biome, the Plinthosols are mainly concentrated in parts of the states of Mato Grosso, Tocantins, and Maranhão, close to the Amazon biome, as shown in **Figure 14**.

Figure 14. Predominant Soil Types in the Cerrado Biome, by Federal Unit



Note: *Only the five predominant soil types in the sample studied are shown.*
Source: *CPI/PUC-RIO with data from EMBRAPA (2020), 2024*

The Contribution of Credit to Meeting the ABC Plan Target

In light of the results presented, this work seeks to answer the following question: What is the contribution of the credit in achieving the targets set by the ABC Plan, which was in effect from 2010 to 2020? The plan features a series of initiatives, with subsidized credit being one of the most important tools for implementing its objectives.[28] While the benefits of pasture recovery can have a number of benefits for the country, it is essential to evaluate the effectiveness of the credit tool in promoting these benefits, in order to make the necessary adjustments to ensure that this tool is effective in achieving the target set for the ABC+ Plan (2021-2030). Additionally, this analysis informs the scaling of efforts needed to implement the PNCPD, which must also operate through financial instruments.

To answer this question, three analytical exercises are conducted: the first uses the estimated impact of the credit on the percentage of pasture area with signs of degradation (low or medium quality); the second examines the impact on the conversion of pasture areas to other uses; and the third presents a hypothetical scenario where the entire pasture area of the enterprises is recovered. The first provides a detailed measure of the impact on pasture recovery, providing a more direct contextualization within the goals of the ABC Plan, while the second allows us to assess the credit's ability to influence changes in land use, potentially converting pastures at various levels of degradation into other uses. The third exercise shows the maximum potential contribution of the credit towards the pasture recovery target, assuming 100% effectiveness of the instrument. As the first two estimates are based on coefficients calculated from the total area of the polygons, the recovered pasture area is included within the converted area.

Firstly, we calculate how many reais of released credit are required to recover (or convert) one hectare of pasture within the study sample, focusing on *ABC Recuperação* credit operations in the Cerrado from 2016 to 2018. To do this, we use the impact observed six years after the credit issuance as a benchmark, which is the maximum observable period from the data obtained via MAPBIOMAS, which runs until 2022. This approach assumes that operations initiated in 2017 and 2018, for which we can observe the state of the pastures for up to five and four years post- credit, respectively, would behave similarly to those started in 2016, when observed six years after contracting. We then multiply this coefficient by the total area of the polygons to estimate the number of hectares recovered or converted within the sample. Then, the total resources mobilized for these contracts is divided by the area recovered/converted, arriving at the desired figure. The results are presented in **Table 2**.

28 Incidentally, the plan originally envisaged that the target would be achieved entirely through finance, as shown in the table on page 84 of the document presenting the plan (MAPA 2012).

Table 2. Estimated Contribution of *ABC Recuperação* Credit to the ABC Plan Target

	Sample (Cerrado, georeferenced operations 2016–2018)		
	1. Pasture recovery	**2. Pasture conversion**	**3. Hypothetical scenario: complete recovery**
Impact coefficient	3.8%	10.3%	72.3%
Total area of polygons		358,314 ha	
Recovered/converted area	13,702 ha	36,810 ha	259,010 ha
Amount of credit released		R$ 976.6 million	
R$/hectare recovered/converted	R$ 71,274.60	R$ 26,531.10	R$ 3,770.50
	Extrapolation (all biomes, 2010–2020)		
	1. Pasture recovery	**2. Pasture conversion**	**3. Hypothetical scenario: complete recovery**
Amount of credit released		R$ 10,079.9 million	
Recovered/converted area	141,423 ha	379,927 ha	2,673,352 ha
Percentage of ABC Plan target	0.9%	2.5%	17.8%

Note: *The credit values for the sample are obtained from the sum of all the operations linked to the "ref_bacen" codes that have at least one ABC Recuperação operation (ref_bacen + nu_ordem). For the total ABC Recuperação credit, the figures are obtained in the same way for the 2016–2020 period. For the 2011–2015 period, it is not possible to fully observe the pasture recovery sub-program. Therefore, the average percentage of the value of ABC Program contracts in the 2016–2020 period that went to ABC Recuperação, 47.1%, is applied to the total resources invested in the program in the 2011–2015 period. The data was obtained from SICOR between 2013 and 2020 and from the RECOR for 2011 and 2012. No figures were found for the ABC Program in 2010. In all cases, the IPCA deflator was applied with reference to December 2020.*
Source: *CPI/PUC-RIO with data from SICOR/BCB (2024), RECOR/BCB (2012), LAPIG/MAPBIOMAS (2022), and EMBRAPA (2020), 2024*

The figures obtained based on the impact estimates are R$71,300 per hectare of recovered pasture and R$26,500 per hectare of converted pasture. These figures significantly exceed the typical cost of recovering degraded pasture, which is usually around R$3,000 (Carlos et al. 2022). This is partly due to the fact that *ABC Recuperação* credit is not only used for the pasture recovery operation itself, but also for hiring technical assistance, purchasing animals, machinery, etc.

The small coefficients found in the study significantly influences this result. If the program were 100% effective, i.e., if it recovered the entire declared pasture area, the cost per hectare would drop to R$3,700, aligning more closely with other estimates (Carlos et al. 2022). Within the study sample, it is estimated that 13,700 hectares of pasture were recovered, and 36,800 were converted as a result of the *ABC Recuperação* credit. However, the recovery potential would be 259,000 hectares if the entire declared pasture area were recovered.

Applying the R$/hectare estimate across all credit directed to *ABC Recuperação* over the period of the ABC Plan (2010-2020) generates a figure of R$10.1 billion, at December 2020 prices.[29] This estimate results in an area of 141,000 hectares of degraded pasture recovered and 380,000 hectares of pasture converted through the *ABC Recuperação* credit instrument between 2010 and 2020. If the maximum potential for recovering these areas had been reached, it is estimated that the credit could have recovered 2.7 million hectares of degraded pasture during the period in which the ABC Plan was in force.

The figures found from the study's impact estimate correspond to 0.9% and 2.5% respectively of the ABC Plan's target to recover 15 million hectares of degraded pastures by 2020. This suggests that the credit instrument, specifically designed to promote pasture recovery in the country, would have contributed very little to the target set. It is possible, of course, for rural producers to recover pastures without resorting to the ABC Program, or even without resorting to credit. However, the limited impact of a policy designed for this specific purpose underscores the need for improvements, to ensure that any increase in resource allocation to the program leads to more effective outcomes.

Even so, if it had been fully effective, the credit would have been responsible for 18% of the target, so its achievement would have depended heavily on the adoption of pasture recovery techniques in other locations that did not receive *ABC Recuperação* credit. According to the Ministry of Agriculture and Livestock *(Ministério da Agricultura e Pecuária* - MAPA), the target of 15 million hectares of pasture recovered in the decade 2010-2020 would have been achieved (MAPA 2023b), which is based on LAPIG's estimate that 26.8 million hectares of pasture would have been recovered in Brazil in this period (Ferreira Júnior et al. 2020). It is worth noting that this figure refers to the amount of pasture area observed in 2010 that changed from degradation classes (severe, moderate or mild) to no signs of degradation in 2018, regardless of whether or not specific ABC Plan instruments were used, including credit. The same study also identifies areas that were degraded in the period (10.1 mha) and new pasture areas (30.8 mha) that also show at least some level of degradation. In addition to this study, Manzatto et al. (2020) estimated the potential for pasture recovery in *ABC Recuperação* contracts between 2010 and 2013 using two different approaches, arriving at figures that vary between 3.3 and 10.4 million hectares recovered. However, this estimate assumes that the area declared for finance is entirely recovered.

29 As it is not possible to observe the subprogram in all the years in the BCB's data, this figure needs to be estimated. The note after **Table 2** explains how this figure was arrived at. In nominal terms, the figure calculated was R$8.08 billion, very close to an estimate used by MAPA, of R$8.13 billion for the period 2013-2020. Learn more at: MAPA (2023a).

Sensitivity Analysis of Results

Econometric Specifications

As outlined in the methodology section, equation (1) includes additional controls that were not used in the main specification used throughout the document. This specification can be found in the first column of **Table 3**. The other specifications add controls cumulatively. As can be seen, controlling for secondary vegetation and specific linear trends for each predominant soil type does not significantly impact the results (columns 2 and 3). However, adding year fixed effects (column 4) reduces the magnitude of the effects and their statistical significance, without qualitatively altering the direction of the results. Allowing these year fixed effects to interact with the land use percentages in the first year (2000) yields a similar outcome. This is because the variation explored in this study comes mainly from the timing of the credit operation, so the year fixed effects compete with the variation used to identify the effects. In the case of the results for the proportion of pasture area with signs of degradation in the polygon, all the specifications generate effects of similar magnitude, in the same direction and without statistical significance.

Table 3. Average Effects of *ABC Recuperação* Credit on the Proportion of Total Pasture Area and with Signs of Degradation over the Polygon Area, with Different Econometric Specifications

	(1)	(2)	(3)	(4)	(5)
Effect on % of pasture	-2.97** (0.78)	-2.51** (0.96)	-2.41** (0.90)	-0.94 (1.19)	-1.46 (1.30)
Effect on % of degraded pasture (medium + low quality)	-1.15 (0.89)	-1.15 (0.93)	-1.07 (0.91)	-1.25 (1.20)	-0.40 (1.27)
Polygon fixed effect	✓	✓	✓	✓	✓
Linear trend	✓	✓			
Secondary vegetation		✓	✓	✓	✓
Linear trend by soil type			✓	✓	✓
Year fixed effect				✓	
Land use * year fixed effect					✓

Note: *Effects estimated from equation (1) with different specifications. Coefficients expressed in percentage points. Standard errors clustered by predominant soil type in the polygon in brackets. Statistical significance levels: *** p-value less than 0.01; ** p-value less than 0.05; * p-value less than 0.1.*
Source: *CPI/PUC-RIO with data from SICOR/BCB (2024), LAPIG/MAPBIOMAS (2022), and EMBRAPA (2020), 2024*

Results for All Biomes

As mentioned in the methodology section, pasture quality data is more reliable in the Cerrado biome, where the majority of *ABC Recuperação* credit operations are concentrated, which is why the publication focused on this biome. However, a significant portion of the resources are invested in the Atlantic Forest and Amazon biomes, which account for 23% and 21% respectively of the polygons associated with *ABC Recuperação* credit operations between 2016 and 2022. Consequently, the results are presented without biome restriction. These results should be interpreted with greater caution, as pasture quality data is less reliable in humid biomes. The other biomes (Caatinga, Pantanal and Pampa) have a very small volume of observations and therefore have minimal impact on the results.

Overall, the general results are largely consistent with those observed in the Cerrado. The coefficients are slightly higher in magnitude and generally have greater statistical significance (possibly due to the greater number of observations), but the conclusions of the analysis do not change, as shown in **Table 4**.

Table 4. Average Effects of *ABC Recuperação* Credit on Various Variables of Interest (Percentages of Polygon Area), Credit Operations Carried Out between 2016 and 2018 in All Biomes

	Pasture (%)	Low quality pasture (%)	Medium quality pasture (%)	High quality pasture (%)	Farming (%)	Soybean crops (%)	Other temporary crops (%)	Crop-cattle mosaic (%)	Natural forest (%)	Planted forest (%)	Non-forest native vegetation (%)
Effect of *ABC Recuperação* credit	-4.08*** (0.33)	-0.89 (0.68)	-2.37** (0.82)	-0.82* (0.34)	1.41*** (0.25)	1.19*** (0.24)	0.52** (0.20)	0.72** (0.20)	2.06** (0.57)	-0.03** (0.01)	-0.13 (0.10)

Note: *Effects estimated from equation (1) with the specification without additional controls (only polygon and linear time trend fixed effects). Coefficients expressed in percentage points. Standard errors clustered by predominant soil type in the polygon in parentheses. Statistical significance levels: *** p-value less than 0.01; ** p-value less than 0.05; * p-value less than 0.1. The crop-cattle mosaic is an undefined area between crop and pasture.*
Source: *CPI/PUC-RIO with data from SICOR/BCB (2024), LAPIG/MAPBIOMAS (2022), and EMBRAPA (2020), 2024*

Results for Credit Operations Contracted between 2016 and 2021

The study focused on *ABC Recuperação* credit operations conducted between 2016 and 2018, given that information on land use and pasture quality is observed until 2022. This allows the results of the program to be measured at least four years after credit issuance, and up to six years in the case of operations started in 2016, which can be considered a reasonable period to observe some effect on pasture recovery.[30] However, the same methodology could be used to estimate the effect of the program over the entire period, including operations that took place in later years (with the exception of 2022, as this is the last year of land use and pasture quality data). In this case, effects can be observed up to three years post- credit for operations started in 2019, two years for those started in 2020, and only one year for those started in 2021, which tends to further reduce the magnitude of the coefficients.

The findings from this analysis align with the main results of the study, as summarized in **Table 5**. There is a marginal reduction in pasture area, with evidence of conversion of medium and high quality areas. On the other hand, the result indicates a statistically significant expansion in the area of low quality, albeit of a small magnitude (2 p.p.). There is a small and statistically significant increase in crop-cattle mosaic areas. No significant effects are found for areas of native forest or non-forest vegetation.

Table 5. Average Effects of *ABC Recuperação* Credit on Various Variables of Interest (Percentages of Polygon Area), Credit Operations Carried Out between 2016 and 2021 in the Cerrado

	Pasture (%)	Low quality pasture (%)	Medium quality pasture (%)	High quality pasture (%)	Farming (%)	Soybean crops (%)	Other temporary crops (%)	Crop-cattle mosaic (%)	Natural forest (%)	Planted forest (%)	Non-forest native vegetation (%)
Effect of *ABC Recuperação* credit	-2.21** (0.32)	1.94** (0.74)	-2.38** (0.76)	-1.77** (0.51)	0.07 (0.34)	0.29 (0.19)	-0.02 (0.26)	1.76*** (0.31)	0.36 (0.37)	-0.11** (0.04)	-0.05 (0.09)

Note: *Effects estimated from equation (1) with the specification without additional controls (only polygon and linear time trend fixed effects). Coefficients expressed in percentage points. Standard errors clustered by predominant soil type in the polygon in parentheses. Statistical significance levels: *** p-value less than 0.01; ** p-value less than 0.05; * p-value less than 0.1. The crop-cattle mosaic is an undefined area between crop and pasture.*
Source: *CPI/PUC-RIO with data from SICOR/BCB (2024), LAPIG/MAPBIOMAS (2022), and EMBRAPA (2020), 2024*

30 Depending on the management techniques adopted and the initial level of degradation, this time can vary greatly. However, in many cases, maintenance fertilization is already recommended between two and three years after the recovery techniques have been fully applied (Zimmer et al. 2012). Additionally, in order to be economically and financially viable, the investment must have a quick payback, so the area cannot remain unused as pasture for long.

Robustness Test: Polygon Size

There does not seem to be any significant heterogeneity in the results with regard to the size of the polygons. The robustness of the results against potential inaccuracies in pasture quality information at the polygon level was assessed by systematically removing polygons from the sample based on the deciles of their area distribution, as detailed in Table 6. Notably, removing the first decile already removes polygons larger than 6.25 hectares (the pixel size of the MODIS data used by LAPIG to create the quality classes), which are kept in the main specification (column 1). In column 2, the first decile of the distribution is removed, leaving polygons with an area greater than 16.7 hectares. In column 3, the first and second deciles are removed, leaving polygons with a minimum area of 31.8 hectares, and so on until only the 30% largest polygons remain, which have an area of more than 180 hectares. The point estimates and levels of statistical significance remain largely consistent across all specifications for both pasture area and for degraded pastures (low and medium quality). Given that precision issues typically affect smaller polygons more significantly, the fact that the result is practically the same for larger polygons suggests that improving data precision is unlikely to substantially change the study's main findings.

Table 6. Average Effects of *ABC Recuperação* Credit on the Proportion of Total Pasture Area and with Signs of Degradation over the Polygon Area, Varying the Sample According to the Polygon Area Distribution Deciles

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Effect on % of pasture	-2.97**	-2.97**	-3.00**	-3.02**	-3.06**	-2.97**	-2.93**	-2.95**
	(0.78)	(0.78)	(0.78)	(0.80)	(0.79)	(0.78)	(0.91)	(0.88)
Effect on % of degraded pasture (medium + low quality)	-1.15	-1.15	-1.17	-1.24	-1.29	-1.30	-1.29	-1.34
	(0.89)	(0.90)	(0.90)	(0.92)	(0.91)	(0.96)	(0.99)	(1.05)
Number of observations	51,497	46,345	41,193	36,041	30,889	25,737	20,585	15,433
Number of polygons	2,239	2,015	1,791	1,567	1,343	1,119	895	671
Minimum area	0	16.7	31.8	48.3	65.7	91.4	128.3	179.6
Deciles removed	**None**	**10**	**10-20**	**10-30**	**10-40**	**10-50**	**10-60**	**10-70**

Note: *Effects estimated from equation (1), with the specification without additional controls (only polygon fixed effects and linear time trend), cumulatively removing part of the sample according to the polygon area distribution deciles, measured in hectares. Coefficients expressed in percentage points. Standard errors clustered by predominant soil type in the polygon in brackets. Statistical significance levels: *** p-value less than 0.01; ** p-value less than 0.05; * p-value less than 0.1.*

Source: *CPI/PUC-RIO with data from SICOR/BCB (2024), LAPIG/MAPBIOMAS (2022), and EMBRAPA (2020), 2024*

Results Restricting the Declared Polygons to Pasture Areas

The polygons declared for *ABC Recuperação* credit operations are not exclusively made up of pasture. Polygons in the study sample at the time of the credit operation were composed of 72.3% pasture on average. This indicates that over a quarter of their areas include other land uses such as crops and native vegetation. There is considerable variability in this figure, some polygons are composed almost entirely of pasture, while others appear to encompass entire properties, featuring a mix of pasture areas interspersed with forests, bodies of water, crop areas, and other uses.

To mitigate potential errors in the declaration of the pasture area to be recovered, an exercise of redefining the boundaries of the declared polygons was conducted, taking into account only the pasture area within these areas, considering the state observed in the year of the credit operation. However, estimating the results in this scenario generates very similar results to the main approach. Naturally, some coefficients increase in magnitude as the area of the polygons is reduced. But this increase is marginal and does not alter the conclusions of the study, as detailed in **Table 7**.

Table 7. Average Effects of *ABC Recuperação* Credit on Various Variables of Interest (Percentages of Polygon Area), Credit Operations Carried Out between 2016 and 2018 in the Cerrado with Polygons Restricted to Pasture Area in the Year of the Credit Operation

	Pasture (%)	Low quality pasture (%)	Medium quality pasture (%)	High quality pasture (%)	Farming (%)	Soybean crops (%)	Other temporary crops (%)	Crop-cattle mosaic (%)	Natural forest (%)	Planted forest (%)	Non-forest native vegetation (%)
Effect of *ABC Recuperação* credit	-4.05*** (0.69)	1.60* (0.74)	-3.48*** (0.68)	-2.18*** (0.52)	0.40 (0.21)	0.78*** (0.11)	-0.27** (0.07)	1.46*** (0.16)	2.04*** (0.41)	0.00 (0.00)	0.02 (0.12)

Note: *Effects estimated from equation (1) with the specification without additional controls (only polygon and linear time trend fixed effects). Coefficients expressed in percentage points. Standard errors clustered by predominant soil type in the polygon in parentheses. Statistical significance levels: *** p-value less than 0.01; ** p-value less than 0.05; * p-value less than 0.1. The crop-cattle mosaic is an undefined area between crop and pasture.*
Source: *CPI/PUC-RIO with data from SICOR/BCB (2024), LAPIG/MAPBIOMAS (2022), and EMBRAPA (2020), 2024*

Conclusion

The analysis indicates that the *ABC Recuperação* credit does not significantly increase the overall quality of pastures and results in only marginal changes in land use. Additionally, the areas designated for pasture recovery investments experienced replacement of native vegetation with agriculture before the credit was obtained, which directly contradicts the primary goal of the pasture recovery initiative, which is to avoid new deforestation and GHGs emissions.

The study includes a series of complementary analyses to address potential data limitations, but the main results remain unchanged. Therefore, empirical evidence using the best data available indicates that the *ABC Recuperação* credit line is not very effective. It is important to undertake additional research efforts to better understand the challenges to implementing the recovery of degraded areas.

Pasture recovery is a critical agenda for Brazil, which needs to balance increased agricultural production with the preservation of native vegetation. To achieve this, public policy instruments must be effective. The public resources allocated to subsidized credit must yield tangible environmental benefits. This study helps identify ways to improve the credit line designed specifically for this purpose, which is the main instrument for operationalizing the ABC Plan.

Enhanced monitoring of areas after credit disbursement is crucial to ensure compliance with the technical project submitted to obtain the funds. This is necessary in addition to the monitoring already carried out by the financial institutions, which primarily focuses on evaluating payment conditions and resource utilization. Systemic assessment of the environmental conditions of the projects is essential to identify challenges to implementing the recovery practices for degraded pastures. While these checks can be expensive, costs can be mitigated by implementing a sample check or using satellite data as a first line of action, identifying priority areas such as those lacking improvement in quality.

Additionally, the ex-ante evaluation of declared projects must be improved. The declaration of the areas that will receive these investments should actually reflect the pasture area to be recovered. Analysis indicated that more than a quarter of the areas declared did not correspond to pasture at the time the credit was issued. Additionally, evidence of deforestation was found before the credit was issued, which suggests that at least part of the pasture to be recovered may have been recently converted native vegetation. As resources are scarce, it is important to focus them on producers who consistently adopt sustainable practices, and to restrict access to producers who deforested in the period before taking out the credit. A credit line for low-carbon crops should not benefit producers who have recently deforested.

Credit can be leveraged more effectively when integrated with other public policies. Hiring technical assistance can be a determining factor in achieving more significant results. Producers who use credit to hire technical assistance manage to rehabilitate more severely degraded areas, which is not observed in other contracts analyzed. When investments are not made correctly and maintained properly, it is possible for the pasture to degrade again over time. Technical assistance helps prevent this from happening, ensuring a more lasting transformation. Despite this, only a small proportion of producers allocate resources for technical assistance. According to both producers and financial institutions, there is still a lack of knowledge about the technologies, as well as a high risk aversion to investing in resources that yield long-term returns (Pereira et al. 2023; Harfuch, Romeiro and Palauro 2021).

Credit for pasture recovery can yield better results when combined with risk mitigation instruments. Climate risks, such as prolonged droughts, are beyond the producer's control and can limit the success of the investment (Pereira et al. 2023). As these are long-term operations, it may be necessary to pair credit with longer-term rural insurance policies.

Additionally, economic factors can affect the financial viability of the venture (Harfuch, Romeiro and Palauro 2021). During the implementation period of recovery techniques, part of the area may become unsuitable for agricultural use, potentially impacting the income of producers, especially smaller ones. In this context, providing a transitional income during the initial years of the operation can facilitate the full implementation of the techniques.

The urgency of pasture recovery in the country prompted the launch of the PNCPD in 2023. Indeed, resources are needed to increase the productivity of already open areas and reduce deforestation pressures. However, the expansion of resources must be coupled with more effective investments. This work has conducted a rigorous evaluation of *ABC Recuperação* credit, providing valuable insights to understand and improve existing policies. Its lessons should be incorporated into the design of other programs with similar objectives.

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